2021 Investor Meeting

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MICHAEL SULLIVAN | Corporate Vice President, Investor Relations

Hello and welcome everyone to the Applied Materials 2021 Investor Meeting.

I'm Mike Sullivan, head of investor relations. I'm going to describe today's agenda and explain how you can join us in the Q&A session later. Today's event will conclude by 2PM eastern time, including the Q&A session. The first section of our meeting will be hosted by Gary Dickerson, our president and CEO. He'll talk about our markets, present our strategy, and take you deeper into our semiconductor technology. He'll invite several of our general managers and customers to join him along the way.

The second section of our meeting will be hosted by Dan Durn, our senior vice president and CFO. He'll talk about our business model and invite Ali Salehpour to discuss our opportunities in Service and Display, also with the insights of our customers. Then, Dan will share his perspective on the semiconductor industry outlook and deliver our new financial model. After Gary summarizes the presentations, I'll join Gary and Dan to moderate the Q&A session. When that time comes, you'll be able to submit a question using the Q&A button on your screen. If you've requested an audio link, you'll be able to ask your question directly.

But there's one more thing. Applied has a strong pipeline of new products and technologies that we've been developing over the past several years but can't fully describe in today's meeting. So we're also hosting a series of events called “Master Classes,” where we'll preview technology inflections and show you how the roadmap is evolving together with industry experts, including our customers.

Our first Master Class will cover memory technology and take place on May 5th.The second Class will be on the 16th of June and focus on logic technology. In the second half of the calendar year, we'll hold Master Classes covering specialty semiconductors, heterogeneous design and advanced packaging, and inspection and process control. We hope you'll join us.

And now, with that introduction, I’m pleased to welcome Gary Dickerson.

GARY DICKERSON | President and Chief Executive Officer

Thanks Mike. And thanks to everyone joining our event today.

While our Investor Meeting in 2021 looks different from the past and we miss seeing everyone in person – we are excited to connect with you virtually and share our outlook for the industry and Applied Materials.

As many of you know, I've spent almost four decades working in semiconductors and I strongly believe this is the most exciting time in the industry's history. Semiconductors are more strategically important to the global economy than at any time in history and this is driving new waves of silicon consumption. As an industry we're in a privileged position where our combined technologies can drive a huge positive impact on a global scale. Before we dive into the details, I'll highlight the five key messages that I would like everyone to remember by the end of today's event.

First, Applied's markets are more attractive with more opportunities than ever. The AI inflection is driving a new era of innovation and secular market growth. It's clear that the future is not going to be like the past. AI computing workloads require new semiconductor solutions at a time when traditional Moore's Law scaling is slowing down. The new PPACt playbook that will shape the industry's future will be enabled by advances in materials engineering and materials to systems co-optimization.

Second, we have aligned our strategy and investment to position Applied as the PPACt enablement company. We have the broadest and most enabling portfolio of unit process technology spanning materials creation, modification, removal and analysis. This allows us to combine these technologies in unique and highly enabling ways that no one else can. And we have developed a proprietary methodology and suite of solutions to provide actionable insight acceleration and significantly improve the time to market of new PPACt innovation.

Third, we are shifting more of our business to subscription-style revenues. We have a highly valuable installed base business and over the past 5 years, we have converted a large portion of this from transactional revenue streams, like traditional on-demand spares and support, to stickier long-term service agreements. In addition, we are starting to monetize new products and services using subscription-style approaches.

Fourth, we continue to optimize our portfolio of businesses to drive profitable growth and higher free cash flows.

Finally, we have a high ROI operating model that generates attractive shareholder returns. We have the highest growth potential within our peer group, and we have strong operating leverage as we grow. In our model period, we expect to grow our earnings per share at 1.7 to 2 times our top-line growth.

Here is the framework for our event today. We'll begin with our market outlook, and you'll hear from me as well as some of our customers and partners, about major inflections driving secular industry growth and new opportunities for Applied. Then you will hear from leaders in our semiconductor business – Prabu Raja and Raman Achutharaman. They will describe our strategy, investments and unique capabilities for PPACt enablement. We believe our portfolio is highly enabling and we'll talk about proprietary new capabilities we've been deploying to accelerate actionable insight and time to market.

Then Dan Durn and Ali Salehpour will explain how we are shifting more of our business to subscription-style revenues and integrated solutions. By doing this, we're delivering more value to our customers and capturing more value for Applied. Dan and Ali will also describe how we are generating attractive free cash flow in our adjacent Display business.

Finally, Dan will bring all of this together by translating our strategy into economic and financial impact, summarizing the progress we've made over the past few years, and then walking you through our new financial model and capital allocation strategy.

So, let's get started.

Today, our markets are being re-shaped by five major inflections that are happening in parallel. First, at a macro level, we see accelerated digital transformation of companies and the economy at large.

Second, we see a major inflection in computing toward AI. These new approaches are needed to make sense of the massive volumes of data being generated and will work best with workload-specific software and hardware. That hardware will be built from customized and entirely new types of silicon – which creates great opportunities for Applied.

Third, the semiconductor industry is inflecting, as the benefits of traditional Moore's Law 2D scaling slow down and the industry transitions to a new playbook to drive Power, Performance, Area-Cost and time to market and there is no company better positioned to enable this new playbook than Applied.

Fourth, as the industry grows, there is an increased focus on ensuring that growth is sustainable and responsible.

And finally, there is a business model inflection. Consumers and companies are migrating away from products and transactions to outcomes and deeper collaboration and partnerships. These five factors combine to create tremendous new opportunities for Applied Materials.

Before I provide more insights into these inflections, I would like you to hear from an industry leader I admire deeply for his creative and thoughtful vision of the future. Until the end of 2020, Young Sohn was Corporate President and Chief Strategy Officer at Samsung. He is currently Chairman of the Board at Harman International and a very successful venture investor including a founding investor in Zoom Communications.

Young, over to you.

"Digital transformation is empowering a data explosion. The pandemic in particular accelerated digital transformation of the economy everywhere. Data is expanding by nearly double every two years. Yet only 2% of data are currently processed. 80% of data are unstructured, turning data into insight through AI is very compute intense.. Silicon and software are critical endeavors. New compute architecture innovation is needed for higher bandwidth and energy efficiency. And hence when thinking about infrastructure for how data are created, stored and analyzed are critical. Generational trends like 5G, autonomous driving, industrial IoT and hyperscale computing are powering the use of AI. The future of the economy and the semiconductor industry are extremely positive and strategic. Applied Materials has exciting opportunities for enabling the future of computing with materials engineering."

Thanks Young!

It is clear that digital transformation will impact almost every area of the economy in profound ways – some of which we may not fully appreciate today. For most companies, embracing digital transformation is non-discretionary because it changes the basis of competition. Those who are first to embrace these new ways of working will emerge as winners, and those who don't adapt to the changes, won't be able to keep up. This is equally true inside the semiconductor industry. In our presentations today, you'll hear about how we're using new digital tools and AI to accelerate the time to market of new technologies and change the way we work both inside the company and with customers.

This is an approach we call 'AI to the power X' – or Actionable Insight Xccelerator. As the world navigates COVID-19 and prepares for a post-pandemic era, the digital transformation of the economy is

accelerating. Companies are re-thinking, and re-engineering, the way they operate, and consumers are making different choices about the way they spend their time, as well as the products and services they buy.

I strongly believe that many of the changes we're seeing today are irreversible, since these new ways of working offer compelling advantages in terms of time and productivity. Digital transformation is built on semiconductor innovation and has significant implications for the electronics eco-system:

We first showed this data generation model in early 2018 and we've updated it regularly. Internally, we call this the data explosion chart. If you compare 2015 to 2021 – data generation has increased more than150 times in just six years.

In 2018, machines surpassed humans in creating data and we moved from an application-centric to a data-first world. We predict that by 2025, even though human data generation will continue to grow, it will only account for about 1 percent of total data generated. In other words, in the future, the industry's growth and economics will no longer be limited by the ability of humans to create or consume data. As everything gets smarter from our phones to our cars to our homes, we are seeing increasing silicon content.

Here, I am showing some illustrative examples, but the trend is clear. What this data shows is significant growth in silicon content per unit over the past 5 years and then continued acceleration of growth over the coming years.

We are still in the early innings of adoption of these trends, as illustrated by the smart home numbers. I am sure that many of us already have voice assistants, security cameras, smart thermostats and appliances in our home today. But, when you divide global sales of smart home products by the 1.6 billion households around the world, you see that on a global basis – penetration is very low today, and there are decades of growth ahead.

All of this is great news for Applied and our customers, but when you look deeper inside these trends, they are actually even more favorable for us. Let's take the first line on this chart – smartphone and double-click to see a more detailed breakdown of the silicon content of a high-end phone.

We've split this by leading-edge logic the application processor, modem and RF, specialty logic the image sensors, Wi-Fi and so on. And Memory the DRAM and NAND. 5G is driving a richer mix of high-end phones that feature more cameras and sensors combined with specialized AI computing. All this adds up to more leading-edge and specialty silicon content per handset.

This is a great example of the robust growth we see in the specialty market and the reason that 18 months ago, we formed a new group inside the company focused on these customers. We call this group ICAPS which stands for IoT, Communications, Automotive, Power and Sensors and they will generate over three billion dollars of revenue this year.

We are still in the early innings of adoption of these trends and another way to look at this is by geography. This model normalizes silicon consumption per capita in the US in 2015 – let's call that baseline 1x. Our model shows that silicon consumption per person will grow faster in the next five years

than it has over the past five. By 2025, China will have only reached the same spending per person as the US experienced in 2015. And India trails China by another 8 to 10 years.

As the global build out of IoT and digital transformation expands, we can look forward to multiple decades of growth. Many in the industry have described the evolution of the market as having four eras of computing, each with increasing pervasiveness. Mainframe computing – with tens of thousands of units PC and internet with hundreds of millions of units. Mobility, a supercomputer and camera in every pocket – selling billions of units. And now IoT and AI – hundreds of billions of connected devices in the coming years. Here we've mapped those eras to semiconductor industry revenues all the way back to 1980. We roughly defined the start of each era. 1990 for the PC era, that was the year when PC sales passed 25 million units for the first time. The year 2002 for the mobility era with the first Blackberry smartphone and 2018 for the AI era as machines generated more data than humans.

What you see is each era adds more than twice as much semiconductor demand as the previous one. I believe AI is going to be by far the biggest wave yet. As an industry, we have line of sight to a trillion-dollar market in the next decade.

So, what are the key elements of the AI era that we need to pay attention to?

At the edge, we're seeing more and more connected devices in many different flavors – Cisco estimated a half trillion by 2030 creating a Yottabyte of data per year. That's ten to the power of 25 bytes of data. Next, we have huge advances in communications including 5G which means it is cheaper and faster to move data around. Next generation communications do more than just enable new applications, they also determine how training and inference workloads will be distributed between the cloud and the edge.

Then, AI is the way to make sense of all the data that's available. Simply put, data isn't very valuable without context, pattern detection, determination and prediction and that all requires AI. So I like to think the value of AI is providing – Actionable Insight. I believe this provides incredible value across every industry, and today you will hear about how Actionable Insight is a key strategy to enable Applied to accelerate value for our customers and outperform our markets.

Traditional computing approaches are not very well suited for the extremely large data sets used in AI and that is driving significant innovation in software and hardware – which is fantastic for the industry. As we move from general-purpose computing to application-specific customized computing, it is important to think differently about the market's needs.

Here we show a way of segmenting the computing landscape. Along the X axis is power consumption and the along the Y axis is computing performance or how many operations per second. What you see is that various zones of innovations emerge, each serving a different set of applications. Cloud data centers where most of the training workloads will be carried out. Edge data centers like autonomous vehicles. Tethered edge devices – like cameras and voice assistants and battery powered edge devices like smartphones and sensors.

Each of these zones will become a battle ground for innovation with customized silicon needed to differentiate and win each type of application. The major focus for all our customers is to deliver the

lowest power, higher performance chips at the best cost to serve each application. A company that has great visibility into this evolving landscape is TSMC.

So, it's my pleasure to ask Dr Mark Liu, Executive Chairman of TSMC to share some of his insights.

“Thank you, Gary, for inviting TSMC to this event.

It has been a great journey to walk along with Applied Materials over the past 30 some years. I remember vividly working with Applied Materials to introduce the first ion implantation tool when I was building TSMC’s first 8-inch fab. Years passed and our partnership grew stronger than ever before. We advanced semiconductor technology frontiers together. Our innovations continued.

Today, the role of the semiconductor industry as a foundational technology is more important than ever. More than half of the world’s population is online. There are more than 3.6 billion social media users and 2.63 billion people stream videos with it. Clearly, semiconductor innovation is at the heart of modern technology advancement. All kinds of innovation ideas are being realized one by one – from human genome deciphering, drug discovery, disease treatment with AI and autonomous driving – to all kinds of digital transformations. We continuously rewrite our vision for the future and enrich people’s lives.

There may be doubters suggesting semiconductor technology advancement is slowing down. Our product data shows otherwise. The power reduction at the same speed or speed gain at the same power, and logic circuit density are still on track to sustain the historical rate for the past 5 generations. That is “power efficiency doubles every two years.” Our coming 3nm will be another full node stride to fulfill this trend.

Beyond 3nm, to sustain this rate of improvement, and I believe we will, we need to work together closer than ever before. We need to innovate in new transistor structures, in new materials, in new system architectures and in new 3D integration. It is an exciting time. We look forward to working with Applied Materials to discover future semiconductor innovations.”

Thanks Mark!

I strongly agree the future is going to look much different than the past, classic Moore's Law and 2D scaling is not going to be enough to enable the future AI infrastructure at the edge and in the cloud.

As Mark described, the industry is transitioning to a new playbook to drive Performance, Power, Area-Cost and Time-to-Market of new devices. This PPACt playbook includes new architectures, new structures, new materials, new ways to shrink geometries and new packaging technology.

Applied is uniquely positioned to accelerate this playbook and to solve our customers' most critical bottlenecks. Based on our collaborations across the eco-system, it is clear that PPAC is the battleground for the future, but the “T” in PPACt, being first to market with winning products, will determine which companies are most valuable in the global ecosystem.

There is tremendous pull and urgency from our customers to accelerate R&D, and quickly ramp to volume production. To illustrate the value of being fast, let me use an example from another part of the eco-system – specifically cloud computing.

Company A started with a lead over Company B and Company B has been trying to close the gap. The value of t is the area between the curves which in this case, we estimate to be 78 billion dollars of revenue and counting. In this period of time, the basis of competition has also changed. Cloud companies started out by using off-the-shelf silicon and in more recent years have formed their own chip design teams to create custom silicon to support specific workloads and differentiate themselves in hardware.

Later in the presentation you'll hear how we are working with our customers to address the area between the curves and capture the value of t. As you can I tell, I have never been more excited about our future growth opportunities. At the same time, I believe that as an industry leader, Applied Materials has a responsibility to ensure this growth is delivered in a responsible and sustainable way.

Last summer, we announced our new 10-year sustainability roadmap. We have taken a holistic approach using our 1x-100x-10,000x framework which describes the relative magnitude of our impact. 1x is our operations and how we run our business,100x is the industry's impact including our customers and suppliers, and 10,000x is how our technology can be used to advance sustainability on a global scale.

Since launching this initiative, the response from our customers and partners has been tremendous. Let’s hear from someone who shares our vision and passion to make possible a better future.

Sanjay, over to you.

”Micron is highly committed to reducing our environmental impact. We appreciate how Applied Materials has embraced similar goals and made strong commitments to increase the eco-efficiency of its manufacturing systems”.

“At Intel, one of our key initiatives is improving diversity and inclusion throughout the supply chain and I am very happy to say as one of Intel’s’ strategic suppliers, Applied Materials has really embraced this commitment. Applied is an industry leader, driving change through investments in unique supplier diversity programs. Supplier diversity and inclusion programs provide new perspectives, expand access to competitive innovation and create a connection with a critical portion of the customer base. On behalf of Intel, I would like to thank the entire Applied Materials team and look forward to continuing our efforts together to create a more inclusive supply chain.” Shaheen Dayal, Vice President, Intel

Thanks Sanjay and Shaheen.

We are making strong progress against the challenging new goals and commitments we've set for ourselves. With respect to climate change, we're on track to reduce our Scope 1 and Scope 2 carbon emissions by 50% by 2030 and to transition to 100% renewable power in the U.S by 2022 and globally by 2030.

We're reinforcing our Culture of Inclusion by committing to even greater transparency, clearer targets and comprehensive training to improve our diversity and inclusion within our company and in the electronics industry at large.

We're expanding our customer and supplier engagements through our SuCCESS2030 and 3x30 programs. And we're working broadly across the ecosystem to drive the advances in technology needed to accelerate AI and the digital economy in an environmentally sustainable way.

We have aligned our strategy and investments around this vision of the future and look forward to bringing more technology innovations to market, while continuing to make a meaningful difference in the communities where we operate and to society at large.

Let's move on to the next section of the presentation and talk about the core of our strategy at Applied Materials which is to be the PPACt enablement company. Over the past few years, we have focused our company around our vision of the future and our customer's evolving technology needs. Our PPACt enablement strategy has three differentiated pillars. First, we have the broadest and most enabling portfolio of technologies spanning materials creation, modification, removal and analysis. No other company has anything close to this breadth of capabilities under one roof. Second, we can combine these technologies in unique and highly enabling ways that no one else can.

One way we are doing this is with a new class of highly differentiated products we call Integrated Materials Solutions or IMS which combines multiple processes and customized metrology and sensors often in a single platform – almost like a fab within a fab. And third, we are more focused than ever on velocity and time to market acceleration. We have developed a proprietary methodology and suite of solutions to provide actionable insight acceleration and significantly improve the time to market of new PPACt innovation.

Underpinning all three pillars of the strategy is our highly differentiated silicon and packaging lab capabilities. We are committed to significantly expanding infrastructure in the United States over the coming years and plan to make major investments to establish new research and development labs that would supplement the innovation infrastructure we currently have which includes the Maydan Technology Center in Silicon Valley and the META Center in New York. With these next generation facilities, world-class talent, and strong partnerships throughout the eco-system, Applied Materials will establish a sustainable new platform for technology leadership to advance the state of chip making for years to come.

Now, to provide more details on our strategy and progress in these areas, I'll hand it over to Prabu. Prabu take it away.

PRABU RAJA | Senior Vice President, Semiconductor Products Group

Thanks Gary.

It is great to connect with you and share how Applied is well positioned to enable PPACt for our customers. There are three elements to our strategy.

First, leveraging our unit process leadership and broad portfolio of products. Second, leadership in developing enabling solutions by uniquely combining our technologies. And third, leadership in accelerating the time to market of PPACt with innovative solutions.

Let's start with a quick look at where the industry is today. First, process complexity is increasing. For example, Materials Interfaces are more important than ever, and Every atomic layer is critical. Variability is now a showstopper. And we see more 3D device inflections. Second, cost is increasing in both R&D and manufacturing. Leading edge fabs cost nearly 20 billion dollars today.

Third, classical 2D scaling has been slowing down, and at the same time complexity is increasing, the market opportunities are becoming larger than ever. And fourth, there's an ecological challenge. We expect massive growth of digital devices in the datacenter and at the edge and this is leading to huge potential increase in energy demand. The need for high speed data connections using today's interconnect technology will consume too much energy.

To address these big challenges, a new playbook is needed to simultaneously optimize power, performance, area, and cost. And to accelerate time to market. This new PPACt playbook is enabled by new architectures, new structures for 3D devices, new materials, new ways to shrink, and advanced packaging and the letter t, arguably most important to capture economic value, is about accelerating time-to-market.

The foundation of the playbook is materials engineering. The new PPACT playbook is driving a number of device inflections. I would like to highlight a few. Everything is becoming 3D, NAND was the first, now 3D GAA transistors, 3D DRAM and 3D interconnects. Wiring resistance is one of the biggest challenges for both DRAM and logic. Also, we see major inflections focused on high performance computing, like packaging and metal gate transistors in DRAM. These inflections provide big growth opportunities for Applied.

Here, I will provide a high-level summary of growth drivers that you will hear about today.

One, mature nodes and specialty semiconductors driven by IOT growth, is benefiting from our unique, broad portfolio. Two, the Future 3D inflections in DRAM and logic play to our strengths. Three, we are just in the early innings of Foundry interconnect and high k metal gate for DDR5.

And finally, our differentiated patterning and packaging solutions are seeing strong customer adoption.

Together, between 2020 and 2024, these provide a total incremental revenue opportunity of 7 billion dollars, and we expect our revenue to grow at a 13% CAGR, compared to the overall market growing at a CAGR of 8 to 9%. I am frequently connecting with all of our customers, and based on our deep R&D collaborations, I feel very positive about the growth outlook for us, with waves of growth opportunities, following one another, especially over the next 5 years.

We are the PPACt enablement company. We are in the right place at the right time. I'll talk about our unit process products first and then cover our unique solutions.

Starting with products, our portfolio is unique, in its breadth and depth. Our products span the spectrum from creating the materials that enable power and performance, shaping and modifying the structures, and unique analyzing capabilities including our leadership in eBeam.

Applied is the only company with both process and metrology capabilities. The only company with full flow labs, for device and packaging integrations, and a technology accelerator, META, to speed up innovations from lab to fab. No other company has this combination of technologies to accelerate the PPACt roadmap

So, our portfolio is unique. And built on over 50 plus years of materials innovation.

Additionally, with our breadth we have connected these leadership products, in new ways, allowing us to deliver completely new PPACt solutions. The first category that I want to introduce you to is ICAPS. ICAPS stands for IOT, Communications, Automotive, Power and Sensors

The ICAPS business group was formed two years ago and is focused on delivering compelling PPACt solutions for specialty devices and mature nodes. By developing new ICAPS-specific products and solutions, for both 200mm and 300mm, we have built deeper collaborations with our customers, resulting in a strong revenue growth for Applied. We now generate more than 3 billion dollars per year in our ICAPS business. Now, let's hear from a leading ICAPS customer, Tom Caulfield, CEO of GlobalFoundries.

“As you all know, GF is the world’s premiere pure-play foundry and we’re focused on a broad, important part of the market for semiconductors in the world. We are one of five foundries of any scale, now six if you include Intel’s announcement last week. To put GF’s partnership with Applied into perspective, I need to first offer some thoughts from the pivot our semiconductor industry made and that has been in the making for over a decade and a half. Our industry began a fundamental shift with the emergence of the smart phone, which brought new and exciting features into a device we each carry in our pocket. It had a camera, it had power management chips, it had touch screen display, it had great audio capability. These are all chips, by the way, that GF produces for its customers. And so the industry made a shift from a compute-centric focus to pervasive deployment of semiconductors – that’s semiconductors everywhere. In fact, in many ways the smart phone led not only to pervasive semiconductors, but it led to the Internet of Things that’s now moving from All Things Connected to All Things Intelligent. As a result, our 80 billion foundry semiconductor industry is now dominated by 70% of that industry for pervasive tech devices. So what does this have to do with Applied Materials? Well Gary Dickerson and team saw this trend early on and created a group dedicated to innovation on adding features to semiconductor products on all nodes. He didn’t limit Applied’s innovation to just transistor scaling. He created the ICAPS team to deliver on this mission. Today at GF, we leverage much of Applied’s capabilities in the for the technologies we innovate and manufacture. Things like embedded memory for secure transactions, and microcontrollers world-class RF technology for connectivity, high-voltage devices for electrification of vehicles, low-power consumption devices for

untethered Internet of Things devices – the technology list is endless. So thank you for a great partnership Applied Materials.

Thank you, Tom.

Moving now to solutions and connected products, we have 3 major offerings where we are seeing tremendous growth in 2021. One, integrated materials solutions or IMS. Two, advanced packaging solutions. And three, the new Applied actionable insight accelerator, which connects our process systems, with our metrology and inspection products, along with unique sensors and machine learning algorithms.

We are building these solutions from a position of strength. We are already number one in foundry and logic, number one in DRAM, number two in NAND, and number one in packaging. And we are using our unit process leadership and domain expertise, to develop integrated solutions for transistors, interconnect, memory, and packaging.

Now, I would like to share our first case study. Applied has enabled the transistor roadmap over the last two decades. We started with selective epi, and then enabled High K metal gates and now advanced FINFETs. Our leadership products such as epi, implant, metal gate, anneal, CMP and selective removal are highly valuable in fabricating lower power and higher performance transistors.

Looking ahead, the next major inflection in transistor structures is Gate-All-around. Let us hear from one of our leading customers, Dr. Hwang, Executive Vice President at Samsung, on his vision for future devices.

“At Samsung, we see a long path ahead for continued performance and cost scaling of our devices. We will take advantage of certain technologies in the years ahead using new 3D techniques, new materials and materials removal technologies, and we look forward to working with Applied Materials as we invent the future at Samsung.”

Thank you, Dr. Hwang, on your 3D devices perspective.

Gate all around provides substantial PPACt improvements. Up to 30% lower power, and up to 15% higher speed. Building gate all around transistors is more complex. It requires multiple new steps in our leadership areas such as Epi, selective removal, metal gate, and gap fill.

Here, interfaces between the materials are critical, and Applied's transistor portfolio and decades of transistor leadership is highly valuable. We estimate that Applied's market opportunity for gate all around to be 1 billion dollars per 100 K wafer starts per month.

With structures going 3D, eBeam is a highly enabling technology, and also a significant growth opportunity. Identifying buried defects is a big challenge for the industry and finding them faster will make a huge difference in our customer's time to market. Our eBeam inspection enables 5 times faster detection of the yield limiting defects. eBeam gives us orders of magnitude more data to see across wafer and across-chip signatures for fast and actionable insights.

In our process control business, we grew revenue substantially over the last four years and are well-positioned to double our revenue over the next four years.

More 3-D inflections are emerging. DRAM scaling is slowing down and expected to reach physical limits. Going to 3D DRAM opens a new direction in scaling for similar to what happened in 3D NAND. But DRAM is very different than NAND due to its performance requirements. The Stack materials need to be conductors in contrast to dielectrics in 3D NAND. Also, the materials need to be engineered for fast device performance and lower power.

So instead of dielectric deposition and dielectric etch, this will be conductor deposition, conductor etch, and selective removal. And these are Applied's strengths. Similarly, chips are reaching scaling limits and we need to consider new ways to route the power and signals. Doing this could deliver chip area savings of over 30%.This results in new steps in the formation of buried and backside rail structures, through silicon vias, and backside processing. These inflections are enabled by our leadership products and solutions

Now, let's change gears and talk about solutions made possible by unique combinations of our technologies. Here's a framework to think about various levels of solutions, as we move beyond unit processes.

The first type, co-optimization of processes, is where we consider how to optimize upstream and downstream steps. About 40% of our products today have an element of co-optimization.

The second type is integrated materials solutions. Interfaces are increasingly limiting PPACt. Any air exposure will impact device performance and yield. Our unique ability to connect our broad leadership products in vacuum provides interface innovations that have huge PPACt benefits. About 30% of our products come designed with this capability.

The third type of solutions connect our process systems with our metrology and inspection products, unique sensors and machine learning algorithms which work as a tightly integrated solution to accelerate PPACt.

Now, let us hear from one of our leading customers, Sanjay Mehrotra, CEO of Micron on the increasing need for solutions.

"As we continue to scale our technology to smaller dimensions, we find that many materials and process technologies that we used in the past are no longer viable. We appreciate how Applied Materials has been working with us to invent new film technologies that are co-optimized with etch technologies, which allows us to speed-up development."

Thanks Sanjay.

As you just heard, co-optimization is very valuable and enables our customers device roadmaps. DRAM chips are key performance enablers for datacenters. And inside the DRAM one of the most critical structures is the capacitor. The capacitor is an ultra-small structure, about 30 nanometer in size,

which is almost 250 times smaller than a blood cell in the state-of-the-art DRAM today, there are 16 billion capacitors in an area that is smaller than a finger nail.

Now, let's talk about the challenge. There is a geometry change combined with further scaling of capacitor dimensions. This is causing a big increase in the aspect ratio which then requires taller hard masks for patterning, And taller masks result in higher etch process variability and defects.

For example, varying mask hole sizes create issues with the final capacitor profile and cause yield problems. Current hard masks and etching no longer work and are limiting capacitor scaling.

At Applied, we developed 3 innovations that helped solve this problem. First, we developed a new hard mask material, Draco, with 30% higher selectivity. With this new material, we can lower mask thickness by 30% which decreases aspect ratio and reduces the burden on the Etch process.

Second, we delivered a new Sym3 etch technology that is tailored for the properties of this new material. Third, we are utilizing a unique non-destructive metrology innovation to measure bottom CD dimensions. This solution helped to accelerate our customers time to market and gave us very significant growth in DRAM CVD and etch revenue.

Bringing a new material to manufacturing is never easy, It needs to drop into an existing process flow, and be compatible with upstream and downstream steps. By co-optimizing for process interactions between deposition and etch, we accelerated the R&D learning cycles. And by using unique metrology, we got better and faster results. Overall, our solutions improved the local CD uniformity by over 50%, and reduced the bridge defects by 100 times, which provides a large increase in yield. Such improvements are only possible because of our breadth and the unique combination of our capabilities.

Our DRAM capacitor hard mask solution provides us with a 1-billion-dollar cumulative market opportunity through 2025. We are already generating revenue and expect it to grow 4 times more by 2024. Now, let's shift gears again and look at integrated materials solutions, and hear a customer perspective from Sanjay Natarajan, incoming Senior Vice President at Intel.

“Intel’s improving our focus on process technology execution to accelerate our product leadership. We look forward to seeing the superior performance and the validation acceleration that comes from in-vacuum step integration. This is what Integrated Materials Solutions promises to provide as Intel continues to drive new ways to move forward on Moore’s Law. We look forward to working with you Prabu.”

Thanks Sanjay.

Now, let's look at an integrated material solution case study for interconnect in leading logic devices. Once again, I will begin by setting the context. A leading-edge mobile application processor has over 11.8 billion transistors, 10 billion via connections, and almost 16 layers of interconnects of varying dimensions, with ones closest to the transistors being very narrow. So, what is the problem here?

As seen on the chart, via resistance is increasing exponentially with the smaller dimensions. And higher resistance equates to higher power consumption. Almost 1/3rd of a chip's power is consumed by the

interconnects. Now, let's look at what causes the resistance to increase. As the dimensions become smaller, interface properties become more significant than bulk properties of the material, and at the narrow via line connection, there are more than 5 materials interfaces.

Interfaces dominate at small dimensions and contribute more than 50% of total resistance. In summary, we need new interface engineering techniques to solve this critical roadblock to performance, power, and scaling. Only a few atomic layers of materials are going to limit your cell phone's battery life.

Here is the good news.

We have been able to solve this challenge by using IMS. Before I show you exactly what we did, let me summarize the approach and the results. A few nodes ago, making an interconnect was less complex. You needed a couple of materials, a few process steps, and conventional process methods. Now we have to carefully engineer the interface. And we have to use our broad set of capabilities including selective processing, metal reflow and many more materials.

On the right chart, you can see the results. With our innovative IMS solution, we have been able to significantly lower the resistance to the level of the previous node, This is a huge PPACt improvement each chip has over 1 billion vias per layer and at least five critical layers. So lowering the resistance can have a huge positive impact on power consumption.

Here is a slide, that explains what you are about to see in the upcoming animation for IMS. The integrated Endura tool on the left, has many different technologies mounted on the same platform ALD, PVD, CVD, interface engineering, surface treatment, reflow, and on-board metrology as shown in the different colors, are all integrated together in vacuum. The cartoon, in the middle, is the magnified image of a copper via structure and the seven steps listed on the right show the process sequence happening inside the tool. Now, here is the video that shows how the IMS solution works.

Wow, that was an incredible sequence of steps, with interface engineering and gap fill with flowing copper at the end!

To summarize, 7 sequential steps, and all done in vacuum. And I want to say, only Applied can do this. These integrated solutions are unique and exclusive to Applied.

Going from 20 nanometer to 5 nanometer and below, the process complexity is increasing, the number of steps more than double, increasing our opportunity by more than 3 times. We have been the leaders in interconnect for over 30 years, evidenced by our strong installed base of over 25,000 chambers on our flagship Endura system. And we have a track record of consistently delivering node over node power efficiency gains.

We just discussed the power and performance challenges of on-chip interconnects; However, interconnect challenges extend to packaging where they impact the overall performance and energy consumption of the system. More advanced packaging is targeted to address these off-chip wiring issues.

Let's hear from Babak Sabi, Corporate Vice President at Intel, who is driving many innovations in this space

"Intel continues to drive advances in heterogenous integration and advanced packaging architectures to deliver ever-growing product design flexibility, power efficiency and overall device performance. With Ponte Vecchio, an exascale GPU, we have brought together our Foveros 3D packaging technology and our Embedded Multi-Die Interconnect Bridge or EMIB 2.5D solution in a product for the first time. These technologies enable the package-level integration of leading-edge xPU silicon, application accelerators, I/O components and High Bandwidth Memory, demonstrating the system-on-a-substrate capabilities required by high-performance compute applications. Applied Materials is and will remain a key partner for Intel in continuing to drive technology advancements in advanced packaging."

Thanks Babak for giving us the opportunity to work with you on this exciting future technology.

Advanced packaging is a growth area that the industry is pursuing with multiple approaches. There are three common goals. First is creating more and shorter interconnects because more I/Os reduce latency, and short line lengths reduce power consumption. Second is 3-D stacking. By stacking devices, we can simultaneously increase bandwidth, reduce power and shrink area. This is now a strategic enabler for system integrations and performance. There are many recent examples. Here is a GPU where advanced packaging helped improve the performance by three times and lower the power by 50%.

Third is chiplets. It provides the ability to customize and use different building blocks to drive application specific performance. It also enables smaller dies and improves yields. Advanced packaging is not a low-end market. It is becoming more and more like front end processing. As the dimensions shrink, process complexity is increasing.

The best solutions come from optimizing a broad portfolio of technologies and combining them in unique ways to achieve system level benefits. What you are about to see now is an animation into the world of advanced packaging. It's meant to introduce you to the building blocks for the off-chip interconnects and the various terminologies you will hear in a minute. You will see that advanced packaging is entirely different from the low-end technology of the past. This is a new era of high process complexity and valuable system PPACt enablement. Here is the video.

It is amazing to see the complex building blocks that make this new kind of system integration possible. Here is a system integration roadmap from bumps, to micro bumps, to TSV and to hybrid bonding. There is a clear step function increase in performance and step function reduction in power. Together, These building blocks enable the future integration of logic, memory and power management devices as a system.

Hybrid bonding, the newest, reduces the interconnect lengths to the micron scale. Let's talk more about this. Hybrid bonding is about the capability to attach chips directly together, and to a wafer. There are two critical modules for hybrid bonding, namely pad formation and bonding. First, pad formation is very similar to the interconnect inside a chip, which we saw earlier. We have a strong product portfolio and decades of expertise in this area. Second, bonding is about placement accuracy and metal to metal

connections. We are excited to be partnering with BESI, an industry leader in packaging, to jointly develop enabling solutions for our customers.

To summarize, packaging is now an important PPACt enabling technology for chip and system performance and a new market for advanced process equipment and know-how. Applied is well positioned with our unique capabilities, a broad portfolio, and a full flow lab where our customers can innovate with us.

Additionally, we have a strong ecosystem collaborations and partnerships, with customers, peers, and research institutes. It is a great growth business for us, with revenue of around 500 million dollars in 2020. And we are still in the early innings of growth.

In summary, we reviewed 3 PPACt case studies for solutions-based approaches. We are combining our technologies, to bring big improvements to our customers' devices. We have a strong pipeline of many such programs, and we are deeply engaged with our customers. We are very excited about the validation results and customer pull for these programs.

Now, I would like to invite Raman to introduce you to something new and exciting, how we are generating actionable insight to accelerate the time to market of these valuable PPACt solutions.

RAMAN ACHUTHARAMAN | Group Vice President, Semiconductor Products Group

Thanks Prabu.

As Gary mentioned at the beginning of today's meeting, PPACt is the battleground, but the “t” in P-PACt is the biggest value driver for all the companies in our ecosystem. In this section, I will talk more about the new Applied AI^{X} platform launched recently. Then I will cover case studies, on how we employ this platform to accelerate customer solutions and Applied's internal R&D.

Speed to solutions and reducing variability are among the top high value problems for our customers. Let's hear from one of our leading customers Dr. Seok-Hee Lee, CEO of SK Hynix semiconductors.

“It’s hard to simply put a number on it, but we all know that improving the process margin is the key to enable technology node migration. In many cases, it not only requires the adoption of advanced new technologies in a number of areas including materials, process and equipment, but it also requires all those factors to be optimized for the integration of multiple process steps. Each change in process variables affect each other at multiple levels, so accelerating the cycle of learning to come up with the optimal solution is crucial. If Applied Materials develops new process technologies which are already co-optimized with adjacent process steps, it will help reduce development complexity for chipmakers. I think our development activities can move at a fast pace if we work together to harness the power of sensors, big data and AI to map and predict the effect of many process variables.”

Thanks Dr. Lee for emphasizing the importance of variability reduction and we couldn't agree with you more.

Before we get into details of how Applied is delivering solutions for PPACt acceleration, let's set the context. Everybody knows about big data and AI. So, why is Applied talking about actionable insight? Our process tools produce over 1 PB of data in a year. Our metrology and inspection tools also generate endless data. There is tremendous data variety and the key question is, how much of that data is actionable for a given context or a given problem?

The truth of the matter is that only a few critical data signatures have a direct correlation to the results or outcomes. We call this Actionable Data. Finding actionable data is like finding a needle in a haystack. Once the actionable data is identified, scaling it with speed becomes important.

Speed in amplifying the actionable data can be a huge differentiator and is the prerequisite for developing actionable insights and better results. At Applied, we have unique actionable data generators, such as, proprietary sensors, modeling, in-vacuum, and eBeam metrology. And we are introducing and deploying AI^{x}: our Actionable Insight Xcelerator platform along with innovative machine learning algorithms to deliver these insights.

The Applied AI^{x} platform brings together process tools, sensors, metrology tools, analytics and machine learning capabilities and is designed to be scalable for new context and new problems. There are 3 elements to the framework.

First, we cannot fix what we cannot see or measure and so having real-time ability to see into the process with in-situ sensors, and on-board metrology is the starting foundation. As you saw in the interconnect case study, air exposure changes interface properties and hence material properties need to be measured in vacuum. This is an example of critical insights from unique actionable data.

As I said before, process complexity is high, we can have more than 10,000 process possibilities for each tool and more than a million combinations for an integrated flow such as the interconnect.

Hence generating actionable insights is vital. Another innovation from Applied that provides actionable insights are our eBeam products. eBeam technology leadership enables us to measure 100 times faster at a 50% better resolution and provide a map with millions of points on a wafer. This gives us wafer and chip signatures that help us learn fast and accelerate PPACt innovations. The last step is to bring all this actionable data into our Applied AI^{x} analytics platform which can be used across all Applied tools.

Some of the key components in here include: ChamberAI, machine learning algorithms for process health, AppliedPRO, or process recipe optimizer for a single tool, or for matching across many tools, digital twin models and integrated control schemes. Our goal is to accelerate every stage of product lifecycle, from R&D, to ramp, and to HVM. Speed and variability are key problems for our customers and with Applied AI^{X}, we can reduce the time by a factor of two and improve the process window by 30%.

Now, I will give a few examples of accelerating time to PPACt solutions.

First, let me refer back to the case study that Prabu covered on the new capacitor hard mask co-optimization solution and provide a little bit more color. Briefly, the hole size variations of the mask impacted the final result and cycle time to the final result was long.

Step one was to find what data was really actionable which was the CD or the hole size at the bottom of the mask. Conventional methods such as TEM are slow and destructive, sample volumes are small.

Hence, scaling up actionable data was critical. Using PROvision, along with its unique imaging along with special algorithms, we were able to get bottom hole size measurements on a massive scale. Massive sampling enabled us to improve the signal to noise and measure the actual variation.

With a 10X increase in sampling, we were able to optimize the process knobs (or settings) and CD uniformity improved 5 times. We were able to deliver better results in a faster turnaround time by combining our leadership in integrated solutions, with our leadership in eBeam, and our differentiated Applied Ai^{x}.

Another example is the recent product launched by our Inspection and Process control team, Extract AI. As geometries shrink, the signal to noise ratio for small defects gets worse. Optical inspection is fast for data capture but has lower resolution while SEMvision has higher resolution but is slower than optical. SEMvision can see and identify the actionable defect data and train the ExtractAI software for defect and noise classification combining ExtractAI with Enlight has the ability to turn an unclassified map of a million potential defects into an actionable map of 1,000 yield-impacting defects.

Finally I want to summarize by providing two case studies of how Applied's AI^{x} platform has helped us accelerate R&D for critical applications and also transfer them to high volume. Etch has very high process complexity. There are more than 100 process knobs, and you can have >10,000, ultrafast changes with transient effects. Chamber components also get eroded during processing and hence real-time conditions are always changing. Every process recipe requires an associated clean recipe that needs to be developed to ensure process stability.

As seen on the charts, by combining the elements of Applied AI^{x} such as the Applied Process recipe optimizer and ChamberAI, we have been able to cut process development time and cleaning recipe development time in half.

Variability reduction and process window expansion are critical to achieving higher yield. Here, I have a case study of how the Applied process recipe optimizer or AppliedPRO was used to find a multi-dimensional optimum, in this case using 7 parameters for an Etch application. Multiple outcomes had to be simultaneously optimized, spatial signatures, at least 2 critical dimensions, and defectivity.

AppliedPRO provides the ability to fingerprint the process space which is important for matching during the transfer to high volume manufacturing.

In summary, Applied AI^{x} is a powerful and scalable platform that connects all the critical capabilities of Applied in new ways to accelerate time to market for PPACt solutions.

We saw many examples of getting better and faster outcomes with this highly differentiated capability that will continue to scale in the future. Applied AIx strongly positions us to solve bigger and more complex problems for customers and the industry.

Now over to you, Prabu.

PRABU RAJA | Senior Vice President, Semiconductor Products Group

Thank you, Raman,

PPACt enablement is the right strategy at the right time.

It is highly valuable to our customers and is highly valuable to Applied. Applied is a company like no other. We have leadership positions in many areas, our product portfolio is unique in its breadth and depth. We can deliver exclusive combinations of technologies in new and innovative ways and we accelerate these combinations with actionable insights.

I have been doing product development for more than 25 years, and the customer pull for our PPACt innovations is the strongest that I have ever seen.

Multiple future inflections give us huge growth opportunities. And by going from unit processes to solutions, we can further expand our growth.

It's truly Applied's time. Our best years of growth are ahead of us.

And now, I would like to turn the meeting over to Dan.

DAN DURN | Senior Vice President, Chief Financial Officer

Thanks Prabu. And thank you to everyone for joining us.

By now I hope Gary's convinced you about the exciting growth opportunity ahead for the entire semiconductor industry. And that Prabu has you understanding why the growth can only be achieved when we overcome challenges like the slowing of classic Moore's Law scaling and the limits of conventional materials and unit processing techniques.

Major inflections are on the horizon including 3D logic, 3D DRAM and advanced packaging and enabling these devices plays to our strengths as a company.

We appreciate the support of our customers today, and we value being their close partner on this journey.

Now, let's move into the second portion of the meeting where we'll discuss our strategy to drive subscription-like revenue. I'd like to link everything you've heard today to a Business Model Inflection.

As Gary explained earlier, we're focusing our strategy on enabling PPACt. We'll continue to deliver great products, but we can make our customers more successful faster, by combining our products and technologies in unique ways.

Prabu and Raman described a continuum, from unit process, to co-optimization, to integrated materials solutions, to digital solutions where we use metrology and AI to provide actionable insights that increase process windows, accelerate time to market and increase yields.

This works depends on sensors, data, and analytics which we're now deploying throughout our business. It's our version of Industry 4.0. As you've seen from Prabu, and as you'll soon learn from Ali Salehpour, we're using industrial IoT and AI throughout the company to enable our customers in new ways.

We're enhancing our products with sensors, connectivity, computing and digital twins. This allows us to digitize everything we're doing. And give customers the actionable insights they need to drive the roadmap and accelerate time to money. With this new technology, we're able to give our customers better insights and better outcomes every day, week and month.

And the best way to deliver outcomes is through subscriptions which give our customers continuous improvement and a more predictable cost structure. And this brings us to Applied Global Services. AGS changed its strategy in 2013. And here you can see not only the growth of AGS, which has accelerated, but also the change in mix to subscriptions.

Until around 2013, AGS was an “after-market” business, selling parts, services and legacy equipment upgrades on a transactional basis. There was a lot of low-cost competition, and not a lot of growth. But the team adopted a true services mentality. It's not just about the after-market: it's about what happens before, during and after our customers transition from R&D to high volume manufacturing.

Giving customers better outcomes during this critical transition accelerates time to yield, time to market, market share gains, and the financial returns on multibillion-dollar investments. So AGS moved from transactions to assurances. First for basics like parts availability and service response times. And then to more sophisticated outcomes based on digital strategies. And the journey continues.

With that quick introduction, I'll now ask Ali Salehpour to discuss how the AGS team is pivoting the business.

And most importantly, why this is valuable to customers.

ALI SALEHPOUR | Senior Vice President, Services, Display

Thank you, Dan.

In this section, it's my pleasure to talk to you about Applied Global Services - AGS.

Earlier, you heard Gary and Dan describe how the company is shifting more of our business to subscription-style revenue. I'll share the story of how we're transforming AGS as we move from on-demand parts and maintenance to customer outcomes delivered through long-term service agreements that have subscription-like revenue.

This has been an exciting journey that's required change in everything we do across the organization. This starts with developing a deeper understanding of the highest-value problems facing our customers.

Then we use technology in new ways to change how we operate all the way from how we engineer and deliver parts to how we service our customers' systems and deploy our network of experts. As we deliver more value, our customers are entrusting us with a larger portion of the money they spend to manage their capital investments.

We are becoming a more tightly integrated part of their operations and a more trusted partner in their success. I'll share some data to illustrate this point later in my presentation. Our goal is to help customers solve much more than just their maintenance problems.

Ultimately, our knowledge of our systems and fab operations is something we put to work helping customers generate better returns on their fab investments through cost, output and yield improvements.

We do this at the leading edge and in the specialty nodes. Today, we have over 14 thousand tools under long-term agreements and the portfolio of services we offer customers are getting more and more advanced. Over the next 15 minutes, I'll describe how we're delivering better and more valuable customer outcomes, uniformly across the largest installed base in the industry.

Before that, let me quickly describe some of the challenges our customers face today.

This is a chart I've shown you before. It represents the lifecycle of a process node. The x axis is time. The y axis is output and yield or; better thought of as revenue and profit for our customers. New technologies and equipment are developed in R&D both at Applied and at customer site, then transferred to a small volume pilot lines and then ultimately progress into high volume manufacturing.

The green line depicts the ideal ramp of the output and yield through these phases of development - we refer to it as the S-Curve. The dotted orange line represents the reality of the ramp a customer must manage.

For a state-of-the-art fab which can cost $20B or more, the difference between the orange line and green line - or what we call the area between the curves - is worth hundreds of millions if not billions of dollars.

Time is incredibly valuable - a delayed ramp means a longer time to returns on these huge capital investments. And the opportunity cost of missing a product cycle or giving up market share to a competitor is even larger than that.

Equally important is the race to get higher yields. The cost of processing a wafer is essentially the same whether 90% of the chips can be sold or only 50%. As chip complexity rises, the ability to generate high yield is getting tougher with every node. Getting things right with a handful of R&D tools is not the same as getting the results across a fleet of many hundreds of tools, each of which can have minor variations at the system level and even at the chamber level.

ASPs are often a function of small differences in speed or power of these chips and that is worth a lot of money. So, the point is that winning companies manage to stay close to the green line at every stage of node development and ramp.

This creates a huge opportunity for Applied to create value for our customers. Our semiconductor customers have more than 40 thousand Applied tools running, and we believe the installed base will increase to over 50 thousand by 2024.

If you add up our customers spending for engineering and maintenance to maximize output and yield, it will grow to over 20 billion dollars by 2024 - which is up almost 50% compared to today. Today, we only capture about 25 percent of this spending which means we have a lot of headroom to grow.

When I started in this role nearly eight years ago, we saw the demand for yield output and costs improvement were underserved in the process equipment market. Gary encouraged us to think ahead about how we can fundamentally change AGS to serve this need.

So, next let me tell you about the journey, the business model we created to meet the need, how the business is performing today and the new growth opportunities we see over the next four years.

Central to our strategy in AGS, is the drive to add more value beyond transactional parts and labor by focusing on better cost, output and yield for our customers. Because we have the largest installed base of tools in the industry, whatever we do needs to be highly repeatable and scalable. So, we created a whole new class of digital services to accelerate PPACt at every phase of the S-curve.

In the beginning, it took us months to craft a service agreement for a specific customer — with mixed results, but we were learning. Over the past five years however, we're using our technology and digital enabled services framework, and we have scaled to over 14 thousand tools that are covered by various levels of subscription agreements.

Our retention rate is over 90% for these subscriptions. I think this really demonstrates that we are delivering great results for our customers and they see these advanced services as highly valuable. In addition, Applied is capturing more value from our installed base and this can been seen in our financial results.

Since 2013, when we started this transformation, we have more than doubled AGS revenues to over 4.2 billion dollars. That's a compound growth rate of 11 percent.

One question our investors sometimes ask is how much of the revenue is recurring, and how much is equipment or WFE? The reality is that companies report differently. At Applied, we treat all 300mm system upgrades and refurbs as WFE. That revenue is reported in our Systems segment.

AGS still manages 200mm equipment upgrades and refurbs because these are legacy systems that are better served by the skills in our team. That's represents only around 10% of the total AGS revenue. So, our business is 90 percent services. In other words, 90% is truly recurring revenue.

When we started, the subscription-like service agreements were only a small fraction of this 90%. But over time we passed 40%, then in 2018 we hit 50% - and in 2020 we reached over 60%. In fact, we've been growing our subscription revenue at 1.5 times the rate of AGS overall, two times the rate of our installed base growth, and over three times faster than our transactional business.

Over the past few years, we've put a huge emphasis on digital services so that we can scale our business effectively and deliver more value to customers. We now have over 4,000 systems connected to our Applied AI^{x} servers, with the server attach rate growing by 35 percent in 2020 alone.

To validate these numbers, we look at third-party analysis. In the 2020 report published by VLSI just very recently, Applied was #1 in service recurring revenue, which is the highest amongst our peers.

We've build a comprehensive cohesive strategy for subscription services that repeatedly deliver better customer outcomes and accelerate PPACt at every phase of the S-curve. This starts by understanding the major challenges of closing the gap between the green and the orange lines. Today, we have a strategy that is increasingly built around digital tools.

We use hundreds of sensors and on-board metrology that generate big data.

Then we use analytics and AI to turn the petabytes of data into actionable insights for our service teams and their customers. This technology is reducing the time it takes to diagnose problems from days, to hours and minutes, to seconds and real-time.

Here we are showing a high-level framework that includes our fleet of systems with their sensors and metrology. It includes: Our AI^{x} server. As you know, AI^{x} stands for Actionable Insight Xceleration, the firewalls to ensure secure access. The applications and analytics our customers, our experts and our data scientists have at their disposal. And the growing database we're building that guides our teams to the best possible outcomes. All of the analysis is customer proprietary and remains that way.

What I'll do next is walk you through specific examples of how we add value in each phase of the S-curve. I am going to start on the righthand side with how we optimize output, yield and cost in high-volume manufacturing.

Before I get into the examples, I would like you to hear directly from one of our customers. Joel Hartmann is an Executive Vice President at STMicroelectronics.

Joel, over to you.

"ST needs to be able to react very quickly to market demands and to our customer expectations in terms of new products and new technology availability. We adopted this strategy a few years ago in Crolles at our 300mm fab in France to grow by second short phases in order to build additional extensions very quickly, ordering and installing equipment very fast and also going very fast on startup, hookup and qualification to reach the highest level of production as soon as possible. We have been working with Applied Materials for many years, but a few years ago in this context, we extended our partnership with Applied for the ability to bring full support to our ramp up and to our technology development needs. For example, full gen development programs. These include qualified resources, fast escalation, support of the factories, speed of logistics and parts supply capability, and also for the technology part, strong support on technology and our differentiated technology program. We also work with Applied Materials on advanced data analytics to improve the performance and stability of the tools and to improve the fab output. These include high-level of equipment data being collected both using ST's IT systems and Applied Materials specific analytics systems. And we're beginning to use some of these solutions, for example exploring predictive maintenance improvement. The data collection systems gives Applied Materials the ability to analyze rapidly offline and to bring solutions to some of the corrective maintenance that we have to deal with. So in a nutshell, I would say that for all these programs we are enjoying this collaboration and we see great promise on working with Applied Materials in the future on these advanced data analytics systems. And we thank them for that."

Thank you, Joel. We greatly appreciate your partnership and look forward to that promising future.

You know, it's been our experience that we can remarkably improve yield output and cost on any fleet of tools we've touched.

Here are 3 examples of the type of improvements we've done at leading edge factories. The first example shows how we've reduced defects and tightened the range of outcomes at a leading foundry customer to meaningfully increase yield. At this leading DRAM manufacturer, we helped boost their output by 7% across a large fleet of tools. And, at one of our NAND customers, we increased output by 4% and widened process windows by 5%, which increases yield.

Then we shifted left, adding services that can dramatically accelerate transfer, matching and ramp. To give you a sense of what this means in the real world, I'd like you to hear from another of our customers, Buddy Nicoson, who is Senior Vice President of global front-end operations at Micron.

Buddy is responsible for all of Micron's DRAM and NAND fabs globally.

Buddy, the floor is yours.

"We've been delighted with the support from Applied Materials in our multiple fab ramps and max out initiatives. The dedicated Applied Materials team with cross-fab matching services has enabled us to accelerate, transfer, ramp and output at our high-volume manufacturing sites. Given the complexity and speed of our product development, Applied's long-term partnership and services continue to be important for the success of our fabs. Applied Materials' resources and supply chain assurance performance has been strong throughout the COVID-19 crisis. Thank you."

Thank you, Buddy, for letting us partner with you to prove the value of our services.

Here is an illustration of an actual case study. Our customer dialed in their recipe on a development tool. Our job was to replicate the results of this “golden tool” to many tools as they transitioned to high-volume manufacturing. In this case, we were implementing a CVD hardmask used in patterning applications where the film uniformity needs to be kept in a narrow range.

We were able to improve the process margin by 61%. And we also worked on output, increasing it by 36%. If we look data from our most recent 50 engagements, our results show that we can typically get to the desired output 2 times faster -- and deliver a 30% improvement in process margin.

The next step - and this is where we are increasingly focused today - is to deploy the solutions and methods to accelerate R&D. Our model is to work both with business unit partners inside Applied and directly with our customers to accelerate their R&D programs. This is helps Applied win more tool sales and, by proving our capabilities in early phases, we're winning more long-term subscription agreements. It is a virtuous cycle that begins with customer satisfaction, which then leads to higher equipment sales, and then to higher subscription revenues and renewal rates.

Here are a couple of real examples. In the first one, we used our Digital Process Recipe Optimizer in an integrated materials solutions engagement for a memory customer. We delivered 50% better uniformity - and we did it 75% faster than our customer's previous best.

On the right side, you can see how we engineered an advanced coating for one of our foundry customers, enabling them to develop a process with four times reduction in particles, which translated to a five percent increase in output and higher yields.

In fact, when we look at our most 80 recent R&D engagements. We've increased the rate at which customers sign up for subscription agreements by 4 times. To my mind, we're still in early innings, both in our transfer and ramp services — and our R&D services. But judging from the value we're delivering and the business outcomes we're enabling, I fully expect these to become another strong vector of growth for us.

Let me quickly summarize by bringing all this together and showing you how this adds up to profitable growth for AGS. Starting with revenue, when we compare average revenue in 2017 through 2020 to the earlier period, we've grown our revenue $1.4 billion dollars per year. We've also grown our operating margins by 300 basis points.

Looking ahead, we plan to grow revenue by $1.7 billion per year and increase operating margin by several hundred basis points. Our goal is to increase subscriptions to 70 percent of our services and parts revenue. And to increase revenue per system by another 20% -- across the entire fleet of the tools. I appreciate the opportunity to share the AGS story with you, and I'll be back a bit later to give you a quick update on our display business.

Dan, I'll turn it back over to you.

DAN DURN | Senior Vice President, Chief Financial Officer

Thanks Ali.

To summarize this section of the presentation, we're using technology to give customers more than better products. We're giving them better outcomes.

We're improving our solutions using technology, and we're delivering them on a subscription basis which gives our customers continuous improvement and a more predictable cost structure. The approach also gives Applied a more predictable and steady revenue stream. According to the latest report from VLSI Research, Applied Materials is number one in both systems and services revenue. We're investing to grow our services business in more ways.

With innovations like Integrated Materials Solutions and Actionable Insight Accelerators that are even more valuable. These programs are in the early stages of growth today, but they're an increasing focus for Applied and our customers, and a key part of our long-term strategy.

Finally, opening up the strategy lens to see and address more of the industry's high-value problems is a great way for us to grow the addressable market for everything we do.

Now, we'll transition to the next section of the meeting: How we're using our materials engineering capabilities we've developed in the semiconductor industry in synergistic markets.

We do this in large end markets where we can solve high-value problems and build sustainable differentiation with our technology. This increases our served addressable markets and gives us additional sources of profit and cash flow.

Today, the best example of this strategy is our display business. I'll now invite Ali Salehpour back to discuss how we built a synergistic business in display; how we've made investments to solidify our technology leadership in areas that are now poised for growth; and how we're positioning the business to deliver higher through-cycle cash flow in the future.

ALI SALEHPOUR | Senior Vice President, Services, Display

Thanks Dan.

Since not everyone knows the story, I'll quickly describe how Applied ported our semiconductor technologies from silicon wafers to glass substrates, creating a large adjacent business for us in Display. We contributed our expertise in both materials engineering and high-volume manufacturing, helping our customers to create the LCD display industry — and grew the market to hundreds of millions of units per year.

Our first products were CVD systems which are critical to building the transistors that controls the pixels. With our expertise in uniform deposition, we were able to help scale the glass substrates through multiple generations of size increases, each time driving down cost. We helped move the LCD technology from the laptop PC market to desktop monitors, and then TVs and smartphones.

Along the way we brought our PVD technology to the display market, giving us more capability to enable faster and lower power transistors. We also adapted our eBeam technology for the display market, allowing our customers to review and analyze defects as well as test transistors. We enabled this to be performed in-line, which improves productivity, yield and cost. A second big wave of growth came when the smartphone roadmap moved to new materials and structures to enable higher resolution, better image quality, sleeker form factors and longer battery life.

These new requirements in the mobile display market resemble the P-P-A-C-C needs in the semiconductor market. And we've worked to help our customers bring these technologies to market faster.

First, we helped enable a new kind of transistor called LTPS that improves display performance. The higher capital intensity of LTPS more than doubled our CVD and PVD opportunity on the backplane. Then, we adapted our CVD technology with a product for OLED thin film encapsulation. This again doubled our CVD opportunity in the smartphone market.

These technology changes created higher annual spending in the display equipment market, which averaged $9 billion dollars per year until 2015, and has grown to an average of $15 billion dollars in the years since.

It's a cyclical market, and we've been “bouncing along the bottom” of the cycle for over two years now, awaiting the next upturn. We've been very active in R&D during this period, strengthening our product lines for the upcycle ahead. Today, we see a number of green shoots in the market. End market demand is strong, and capacity is tight, especially for the large displays.

That's been positive for panel prices and for our customers, giving them the resources to increase their investments as they look to 2022 and beyond. The pandemic hurt consumer spending, but it accelerated trends like work from home, learn from home, and online entertainment and shopping.

As a result, we've seen healthy sales of PCs and tablets. We've also seen growth in the average size of TVs. Unit growth and size growth are two of the three key drivers of the market.

The third is capital intensity, which is also increasing because of the number of new display technologies that are right on the horizon. The end result is that we see a growing number of new fabs being planned, and each fab will need more of our systems.

To maximize our performance in the upturn, we've strengthened our core products in CVD, PVD, yield management and OLED thin film encapsulation. In addition, we've borrowed the concept of Integrated Materials Solutions, so we're now using a combination of our display technology to help our customers accelerate the development of faster transistors that use less power.

Since 2017, in fact, we've released 15 new products. On the backplane, our new products enable metal oxide transistors for OLED TVs. We're also using our LTPS technology to bring the benefits of OLED displays to notebooks and tablets. And we have LTPO transistors which are even faster and lower-power, which is perfect for foldable OLED smartphones. On the frontplane, we've enhanced our thin-film encapsulation technology to support OLED notebooks and OLED TVs.

We've increased our market share with these products which will be great for us in the recovery. As you may know, we've also been developing new technology beyond our core products. The status is: we've completed development, and our customers are evaluating whether to use them in the OLED market. This could give us upside revenue in the future, beyond the horizon of our new target model.

Now that we've strengthened our core products, we're set up for more attractive returns. We'll deliver higher revenue and higher through-cycle operating margin.

As you can see, our strategy has been delivering incremental cash flow. Our operating margin dollars increased to an average of $200 million dollars per year, in the 4 years ending in 2016. As smartphones adopted OLED, and as LCD TVs moved to Gen 10 panel sizes, we grew annual operating margin to an average of $450 million dollars in the four years ending in 2020.

In our target model, we expect the operating margin to grow to an average of $600 million dollars in the four years ending in 2024. With many of our product enhancements now completed, we see a path to higher cash flow in the years ahead.

Our operating margins will increase in 2022, as we transition to our new target model. In 2023 and beyond, we're committed to operating margins of between 25 to 30 percent when revenue cycles between $1.6 and $2.7 billion dollars. This will give us our best-ever through-cycle operating margins and cash flow.

And with that, Dan, it's back to you.

DAN DURN | Senior Vice President, Chief Financial Officer

Thank you, Ali.

And now, we're transitioning to the last section of the presentation.

How we'll take advantage of the market inflections, technology inflections, and business model inflections to generate strong financial returns. And how we'll allocate the capital to fuel profitable growth and return cash to shareholders.

The semiconductor industry will drive the majority of our growth over the next several years, and I'll take a few minutes to show you how our markets have changed and evolved, and why we can look forward to a healthy market in the years ahead. Applied Materials grew up alongside the semiconductor industry. It's been a great driver of our business over a long period of time as semiconductor sales have increased.

The semiconductor industry's first $200-billion-dollar year was in 2000. It took the industry 40 years to get there. The journey from $200 to $400 billion dollars took about 17 years - which is less than half the time. And we could reach the $600-billion-dollar milestone by 2024, again in less than half the time.

Prior to the year 2000, the semiconductor and equipment companies both enjoyed significant growth. But the next 13 years weren't as kind to the equipment industry. In 2000, equipment capital intensity peaked, and we had a no-growth cyclical industry until equipment intensity bottomed in 2013. Since then, we've returned to growth.

Let me explain what happened between 2000 and 2013. Over that period, a number of efficiencies were fully absorbed. One, the productivity of moving from 200mm to 300mm wafers which gave our customers 2.3 times the number of chips per wafer. Two, the greater automation and productivity of these same systems. Three, customer consolidation in leading-edge technology, when a handful of companies came to lead the industry in DRAM, NAND and foundry-logic. This accelerated during the 2009 financial crisis when sub-scale players exited the business and put their factories up for sale. This allowed the remaining companies to buy used fabs instead of building new ones. And four, the foundry model enabled many chip companies to outsource their manufacturing and stop buying equipment.

In fact, equipment intensity slowly declined from around 17% in 2000 to about 9% in 2013. And that was the bottom. By then, all of these efficiencies were fully absorbed, and equipment intensity gradually increased. Specifically, we've experienced new demand drivers. Chip designs have become more complex, requiring more process steps. 2D scaling has slowed and the promise of 450mm wafers has evaporated.

More recently we're seeing a trend toward localized production. It's a better set-up for long-term growth. But many investors wrote off the industry between 2000 and 2013. Others used it as a trading vehicle. And today, many investors are still not ready to trust that this is a growth industry.

Here's an observation I shared with you on our November earnings call. If you plot equipment spending on a rolling 2-year basis, starting with 2012, this is what you get. I like that growth trend.

In fact, equipment spending has more than doubled over the past 8 years - from about $28 billion in 2013 to over $70 billion dollars this year. That's a compound annual growth rate of over 12%. Not every year was a record. And not every year will be a record. But I like the consistency.

It's been a time when investors could “go long” the sector and make money. In fact, if you invested in Applied Materials at the start of this period, your stock gains would have been over 1,100 percent. That's over 2 and a half times the returns of the Nasdaq, and over 5 times the returns of the S&P 500. I believe the semiconductor market will keep growing at a healthy pace. Not every year will be a new record. But I believe there will be higher highs, and higher lows. We will deliver growth.

And I'll wager that equipment spending in 2021 plus 2022 combined will be between $150 and $160 billion dollars. That’ll be the 9th consecutive increase in the 2-year rolling average. And for everyone who's been trained to get a little nervous when they hear the word “record,” yes, 4 of the past 5 years were records. And 2021 will make it 5 out of 6.

But instead of overcapacity, we're seeing the most dramatic global shortages the semiconductor industry has ever seen. The shortages tell us four things. One, there are more demand drivers than ever. Gary showed this in his presentation when he talked about the four eras of computing.

In fact, we've been anticipating this growth for years. This slide is from our 2017 Analyst Day. From PCs, to smartphones and tablets, to an even bigger and more permanent wave that we called the AI Era - the biggest wave yet. Second, this new wave is permanent. It's not consumer discretionary. It's business critical. You adopt the technology, or you fade away. Our company is just one example. We're embracing the technology. It's a catalyst for our strategy. Third, semiconductors are increasingly strategic. Every advanced nation in the world wants to have an assured supply. Because you can't have an advanced economy without it. And fourth, semiconductors are cool again.

We went through a long period where semiconductors were seen as a commodity, and the lion's share of the value accrued to software. I think the shortages have taught us an obvious lesson: great software runs on great hardware, and with Moore's Law slowing, there is there is no more free lunch. And one last observation in this section: while our customers are investing more than ever, they are also more profitable than ever. They are making disciplined investments that they have to make to capture the growth they expect to see in the years ahead.

In summary, will every year be a record? No. But is this a growth industry? Yes. Absolutely. It's higher highs and higher lows. And with Moore's Law slowing, and more of the roadmap being driven by Materials Engineering and a New Playbook, is Applied in a special place? I strongly believe the answer is Yes.

Next, I'd like to talk about the financials. How our strategy is designed to deliver high ROI, cash flows and shareholder returns. I'll start by showing you the journey we've been on, and then layer on our new target model.

This will give you a sense of Applied's growth trajectory in the years since Gary was named CEO in 2013. If I had to describe Gary's philosophy in a couple words, I'd say it's inflection-focused innovation.

The ability to see around corners -- and the conviction to make strong bets aimed at major inflections -- to create differentiated technology and out-sized financial returns. What you see here is that Applied grew revenue by almost 100% between the time Gary joined as President in 2012 -- and 2020.

We grew operating profit grew by more than 200%, and EPS by more than 400%. Comparing 2012 to 2016 and 2020, you see the benefits of the Product Development Engine, with the revenue momentum accelerating and increasing by 59% in the latter period.

And we're talking about profitable growth. We expanded gross margins by 230 basis points through 2016 and by 420 basis points through 2020. We increased operating margin by 590 basis points through 2016, and over 1,000 basis points through 2020.

We think of R&D as an investment. It's fuel for profitable growth, and we've increased it from 55% of opex to nearly 70% today. This drove growth and share gains for Applied and it gave us the most balanced share profile of the major companies. Here you can see that our share used to be high in foundry-logic — and significantly lower in memory.

Today, our share is relatively balanced across foundry-logic, DRAM and NAND. We don't need to lose sleep at night when one spending category is higher than another. Sometimes investors get concerned

when foundry-logic spending is strong. They think it's unusual -- and that there'll be mean reversion and an increase in memory spending.

While it doesn't really matter to us because of our balanced share profile, here are the facts. On average, foundry-logic spending has been over 55% of equipment spending for the past 10 years and for the past 20 years. In fact, there have only been three years in this entire period when memory was above 50%: in 2007, and also in 2017 and 2018 during the transition from 2D to 3D NAND. So high exposure to foundry-logic spending is valuable. Enabling the foundry-logic roadmap and accelerating PPACt is even more valuable.

Now I'd like to summarize the momentum in our reporting segments which is the foundation of our new financial model. Prabu and Ali showed you the individual trends earlier in the presentation. What you notice when you put things side by side is that each segment has been generating revenue growth over the past 8 years. And each has excellent opportunities and well-funded strategies to keep driving the revenue momentum into 2024, which is the year of our new target model.

Comparing 2012 to 2020, you also see profitable growth, with operating margin increases of 670 basis points in semi systems, 310 basis points in AGS, and 290 basis points in Display. Now, it's time to reveal how this translates to the growth we expect to deliver through 2024, from the revenue line, through to margins, and to earnings per share. And especially to free cash flow and shareholder returns. This is our new target financial model.

You'll notice three scenarios: our base case, and also our low- and high-case scenarios. You may be wondering about the WFE assumptions. In our base case, calendar 2024 WFE is around $85 billion dollars; our high case is around $100 billion; and our low case is around $75 billion. In our base case, we expect to grow the company by more than 55% over the next four years.

We expect our highest growth in semi systems, at over 60%. Next, AGS at over 45%. And then Display at over 35%. We plan to increase gross margin by 340 basis points -- and operating margin by 610 basis points. This should produce earnings of $8 dollars and 50 cents per share at a tax rate of 12% and around 875 million shares.

In our EPS bridge, you'll see that our revenue plan generates around 55% of our earnings growth, with margin expansion driving over 35% of the EPS growth and buybacks the remaining 9%.

We expect to grow revenue by about $9 and a half billion dollars with $7 billion coming from semi systems, $1.9 billion from AGS, and $600 million from Display. I'll double-click on semi systems which drives over 70% of the growth plan. We dedicated a lot of today's meeting to demonstrate the value of PPACt enablement to our customers. It's going to be a powerful secular growth driver for Applied for many years into the future.

PPACt enablement represents over 55% of our semi systems revenue in 2020, and we expect it to grow to more than 80% through 2024, becoming around 2/3 of our mix. We're excited about the unique opportunity we have to combine technologies to solve higher-value problems worth billions of dollars to our customers. We feel confident about the momentum we're having with Integrated Materials Solutions

and Actionable Insight Accelerators, two unique and proprietary capabilities that we're constantly improving on to accelerate PPACt for customers.

These exclusive technologies are exactly what the industry needs to overcome roadmap challenges and deliver better logic chips and memories. These innovations give us confidence that we can continue to earn healthier margins over the next several years. We've also been working on important cost components of our margin strategy. We've deployed new systems and processes, and our teams are operating with discipline, generating margin improvements even while we're still experiencing cost headwinds from the pandemic. But R&D is our best fuel for generating profitable growth, and that's why we'll continue to focus around 70% of opex on research and development.

Now let's talk about cash flow. We saw momentum through 2020, but our new model puts us on a higher trajectory. The revenue momentum and margin improvements are setting us up for profitable growth. And we expect to generate around $6.5 billion dollars of cash in 2024, which would be up more than 90% compared to 2020.

And that brings us to our capital allocation philosophy. Our first priority is to keep making disciplined investments to grow and strengthen the business. At the same time, we want to preserve a strong and flexible balance sheet. Beyond that, our goal is to return excess cash to shareholders using a mix of buybacks and dividends. Looking at our track record, you see ratable dividend growth, especially in recent periods.

We've increased the payout in each of the past 4 years. Last month we announced a 9% increase. But most of our capital returns have been through stock buybacks. We anticipated that our opportunities were improving, and we took advantage of that by repurchasing a large portion of shares outstanding. We still believe buybacks are the more attractive way to return cash.

The board recently announced a new $7.5-billion-dollar buyback authorization which supplements the $1.3 billion we had remaining on the prior authorization. And today we are announcing something new. We are now committing to return 80 to 100% of free cash flow.

You've heard a lot of numbers today, so let me recap the financial section before inviting Gary to summarize the meeting and begin the Q&A. By now I hope you share my excitement for the opportunity we see as our end markets accelerate -- and need more of the technology we uniquely provide.

I hope you see why we're making strong, targeted investments to fuel growth and outperform in our markets. We'll push ourselves to improve execution to expand margins, grow earnings and generate cash. And we'll continue to be disciplined in how we allocate capital - while following up on our firm commitment to return cash to shareholders.

Thank you for listening today, and now let me welcome Gary back to the meeting.

GARY DICKERSON | President and Chief Executive Officer

Thanks Dan. Before we move to the Q&A section of the meeting, I'll quickly summarize the key takeaway messages:

First and foremost, Applied's markets are more attractive with more opportunities than ever. Digital transformation of the economy and the AI inflection is driving secular market growth and a new era of innovation.

What comes next is not going to be like the past and the new PPACt playbook that will shape the industry's future will be enabled by advances in materials engineering. We have aligned our strategy and investment to make Applied the PPACt enablement company. We have the broadest and most enabling portfolio of process technologies and we are able to combine these technologies in unique and highly enabling ways that no one else can.

In addition, as you heard from Prabu, Raman and Ali we have developed a proprietary methodology and suite of solutions to provide actionable insight acceleration and significantly improve the time to market of new PPACt innovation.

On top of this, we are shifting more of our business to subscription-style revenues. Over the past 5 years, we have moved a significant portion of our installed base business to recurring revenues and we are starting to monetize new products and services using subscription-style approaches.

In addition, we continue to optimize our portfolio to drive profitable growth and higher free cash flows. This all adds up to a high ROI operating model that generates attractive shareholder returns. We expect to grow our earnings per share at 1.7 to 2 times our top-line growth and, as you've just heard from Dan, we are also making a commitment to return 80 to 100 percent of our free cash flow to shareholders.

Now let's move on to the Q&A section of the meeting.