Bringing you Holiday Cheer, Courtesy of Moore's Law!

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Author's preface: This article is a departure from my usual high-tech language, because I think our industry needs to do more to educate non-technical readers about how their treasured electronic devices got to be so cheap and powerful. Our success in realizing Moore's Law has been one of the greatest achievements in modern science, and we must continue doing all we can to continue that progress. Please feel free to share this essay as a holiday gift to anyone in your life who benefits from the achievements of lithography.

For many, our Christmas holiday cheer is wrapped around getting the latest gadget that brings us more power to do things than we had the year before − be it a new IPhone, iPad, laptop or some other high-tech gizmo. Added to this annual ritual, which we now intuitively expect but do not quite notice, is that we pay less or the same for these gadgets than we did in previous years – even though they may run twice as fast and store three times as many photos and videos. At the heart of this happy surge are the computer chips that grow more powerful every year without increasing their price. I would like to tell you how we in the computer chip industry do this, and what it will take to continue this trend in the coming decades.

Technology was not always like this. Growing up in the early 80s in India, where my dad worked for the telephone company, I remember that when we got a new phone it was the same rotary dial model with just a new exterior body, and maybe a new color. If today's technology were moving at the same speed as then, we would only be getting a new cover for our iPhone or a new computer mouse for Christmas, and not more powerful gadgets.

To understand this phenomenon, we need to look at the leading-edge computer chips that are the heart of all these tools, made by leading chipmakers like Intel, Samsung and others. Inside these microchips are tiny transistors and other circuit elements that do the work. The reason these devices can deliver more power every year at lower cost is because the advancement of computer technology is guided by Moore's Law, named after Gordon Moore, co-founder of Intel Corporation. Moore proposed this law in 1965, saying that number of transistors per square inch would double every two years or so.

We have been able to follow Moore's Law so far by making transistors and other circuit elements smaller every year. Making computer chips takes many steps, the most critical of which are embodied in a process called Lithography, which involves printing the images of circuits. To print smaller and smaller transistors, we need to be able to resolve the printed images. British physicist Lord Rayleigh (1842-1919) pointed us to "knobs" that we can turn to resolve ever-smaller images. Prominent knobs are color of the light for printing (wavelength), design of optics (numerical aperture) and printing under something more dense, like water. We also have also learned lots of tricks (called optical proximity corrections and multiple patterning) that let us keep on printing smaller and smaller features.

The current technology of choice for advanced printing of computer chips is called 193 nm optical projection lithography, which involves a zillion optical tricks and repeats the printing process three or four times to make one image. However, 193 nm has been running out of steam for some time. This means that either we cannot make computer chips more powerful by just shrinking the size of features, or the cost of doing so will be a lot more. Neither of these are acceptable solutions, and that is where Extreme Ultraviolet Lithography (EUVL) comes into play.

EUVL promises to extend Moore's Law by changing the color of light used for printing – from current 193 nm light from excimer lasers to 13.5 nm light from plasma sources. Alas, we cannot see either wavelength with our unaided eyes. This switch of color came with big physics challenges as EUV Light, with its photons of 14x energy, interacts with matter very differently than photons from excimer light. This change has resulted in a massive amount of work over many decades on light sources, optics and photo-sensitive chemicals for developing images. For these reasons, EUVL has taken many decades of worldwide effort and investment and is now expected to be used by leading chipmakers by 2018- 2020 time frame.

We would certainly be lost without the ever-more powerful computer chips that we are now used to having at our disposal every year. So now you know whom to thank for your new holiday gadgets, and you can rest assured that they will keep on working to ensure the benefits of Moore's Law will continue for years to come.