Synchrotrons as a Soft X-ray Source for Lithography

The utility of computer chips in the 21st century cannot be overstated. They are in phones, computers, and even watches. With today's graphics technology we are able to render hyper-realistic images of the world in virtual reality environments. With faster chip speeds and power efficiency, who knows what is possible? In order to make such chips, the standard manufacturing technique is to shine *extreme ultra-violet* (EUV)light (λ = 13.5 nm) on to various wafer masks to achieve the desired feature size. These features could for example be transistors or nanochannels. However, the path forward in the semiconductor industry today is unclear, because in order to achieve smaller transistor sizes, lower wavelength light is required. Smaller transistor sizes (ie: higher transistor density) means an increase in speed and power efficiency for a given chip area. In 1965, Gordon Moore made the observation that transistor density in a given integrated circuit size doubles every two years (Moore's law). This observation is not a fundamental law of physics but more of an empirical relationship observed by experience in the chipmaking industry. The motivation for this thesis work is to develop an accelerator which is capable of producing soft X-rays (λ = 2-7nm) for lithography at similar, or higher intensities as current industry standard sources (λ = 13.5 nm).

In order to use an accelerator to create soft X-rays for lithography (aka: *synchrotron radiation*), one must use so-called insertion devices (aka: *wigglers*, *undulators*). There are a number of parameters which govern the nature of the light emitted from undulators, which will have to be fine-tuned in order to suit the EUV lithography use case. These undulators are really just periodic magnets, and oscillate the electrons back and forth. At every oscillation, the electrons emit a small cone of light in a forward direction. However, given enough oscillations, it actually ends up being a substantial amount of light. The difference however is that light is produced in a much cleaner way than traditional EUV source technology (tin-plasma excitation). This is an advantage because it is very difficult to keep mirror surfaces clean in when plasma is being scattered in all directions. This could be completely avoided using undulators. This advantage increases the uptime of your machine and decreases the amount of maintenance cycles required to run the machine.

To conclude, undulators provide clean and powerful sources of synchrotron light which up until now has been very useful for scientific experiments, but could also be utilized for smaller feature sizes in lithography. Cleaner, lower wavelength light means more uptime and faster chips - a clear advantage over traditional EUV plasma techniques.

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