EDITORIAL

E-BEAM DIRECT-WRITE LITHOGRAPHY/NANOIMPRINT LITHOGRAPHY AND AVIATION

In the last editorial, I wrote about microlithography and aviation. The Wright Brothers' airplane corresponds to the early days of microlithography using proximity printing. Proximity printers are easy to build. Many companies, such as IBM, made their own contact/proximity printers. However, cleanliness and short working distance were inherent problems. The mask or the wafer can be damaged by accidental contact with particles or themselves. The 1X full-wafer-field projection printers were correlated to single-engine unitized-body airplanes: much safer, faster, and cleaner. The 1X handicap was soon removed with 10X and 5X reduction projection printing, similar to multiple-engine planes. Extending the field size with step and scan is similar to aviation moving into the jet age. From 1960 to 1981, jet aircrafts evolved from the Boeing 707 to the Boeing 747. The cruising speed did not increase. Actually, it dropped by close to 10%. However, progress was made in other areas, such as fuel economy, pollution, noise, passenger safety, comfort, and entertainment. For lithography, many times the NA and wavelength improvements were too slow; progress was made from phase-shifting masks, off-axis illumination optimization, optical proximity correction, reduction of vibration, immersion, and polarized illumination.

Aviation technology does support carrying passengers at much greater speed. The supersonic transport (SST) travels at Mach 2.2, more than double the speed of a Boeing 747. For lithography, double patterning improves the resolution close to 2X. However, both technologies are too expensive. They do not sustain forever. Extreme ultraviolet (EUV) lithography drops the wavelength by an order of magnitude from the water-immersed ArF wavelength. It is supposed to open a new horizon for resolution improvement. Similar is the space shuttle. Using rocket propulsion, it is capable of a cruising speed an order of magnitude higher than that of the SST. However, because of the high price tag and enormous requirement of high-tech components, it has not been commercialized since more than a quarter of a century ago. EUV lithography, with its high price tag and stringent requirements on source, optical components, mask, and resists, has a path to commercialization that is similarly lengthy and uncertain.

My favorite next-generation lithography (NGL) technology is multiple-e-beam direct-write lithography. What kind of airplane is it? I could not figure this out in the last editorial but I have found the answer since then. The direct-write tool is like a helicopter. The helicopter can take off and land on any kind of surface. No airport is required. The direct-write tool writes the pattern directly on the wafer. No mask is needed. However, a helicopter is no match for a 747 or a space shuttle in terms of the payload it can carry and the speed it can attain, similar with a direct-write tool compared to an immersion or EUV scanner. Here is where the multiple beams play a role. By employing 100, 10,000, and even millions of beams, the same amount of patterns can be written in a comparable amount of time, just like using ten thousand or a million helicopters to carry the payload of a 747 or a space shuttle.

Let me propose a new question. What kind of flying machine is nanoimprint lithography? Is it a cruise missile that can track the terrain in close proximity with great precision or just a Wright Brothers' plane in disguise? In either case, it is difficult to turn into a commercial aircraft, except for running special errands.

By the way, let me re-introduce the Communications Section of JM^3. Treat it like a Letters to the Editor section. If you have any comment or better analogy, please send it forward. Of course, you can also summit short communications on original work, comments on recent papers, and errata. Contributions must be technical in nature. Original works are reviewed with the same rigor as journal articles.

Happy reading!

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