A self-tuning method for laser beam compensation in Electron Beam Lithography

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In an electron beam lithography (EBL) equipment, a stage is required to move the sample when writing large-scale layouts. However, the stage often has significant errors, necessitating the use of a laser interferometer to measure these errors and subsequently employing a deflector to control the electron beam to compensate for the errors. This technique is also known as laser compensation technology (pull-in). We have conducted an in-depth study on this technology and proposed a method for automatically tuning the compensation coefficients. This method utilizes image recognition technology to achieve sub-pixel level positioning of markers. This tuning method supports compensation for rotation, displacement, and gain terms in laser compensation.

The core innovation lies in the automatic tuning mechanism: the system utilizes high-resolution image recognition algorithms to perform sub-pixel positioning on tiny marks on the layout, obtaining deviation data between actual displacement and theoretical values. Through the mapping relationship between the laser interferometer and the deflector, the rotation, displacement, and gain compensation parameters are iteratively optimized to achieve dynamic adaptive adjustment. Compared to traditional manual debugging, this method does not rely on empirical parameters, can automatically adapt to layouts of different sizes and characteristics of the workpiece table, significantly reducing debugging time and improving consistency.

The technical advantages are reflected in: 1) positioning accuracy that does not rely on the experience of parameter adjustment personnel, with error detection resolution reaching the nanometer level; 2) multi-dimensional compensation capability, which simultaneously corrects translation, rotation, and scale errors; 3) high degree of automation, fast parameter adjustment speed, and the ability to avoid parameter errors caused by beam spot drift.