DYNAMICS IN DEWETTING: THE INFLUENCE OF FLUID PARAMETERS

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Keywords: dynamic contact angle, moving contact line, hydrodynamic assisted dewetting, forced dewetting

ASML is a company producing lithographic scanners for the semiconductor industry. Immersion lithography is one of the latest developments to reduce the critical dimensions in the semiconductor industry. Instead of reducing the wavelength of the exposure light, the Numerical Aperture of the systems can be increased above unity with immersion technology [1]. With this technology the air between the lens and the silicon wafer substrate is replaced by a liquid with a higher refractive index than air. Current immersion systems use ultrapure water as liquid, enabling a minimal feature size smaller than 40 nm. In this process water is supplied and extracted below the projection lens (Fig. 1).

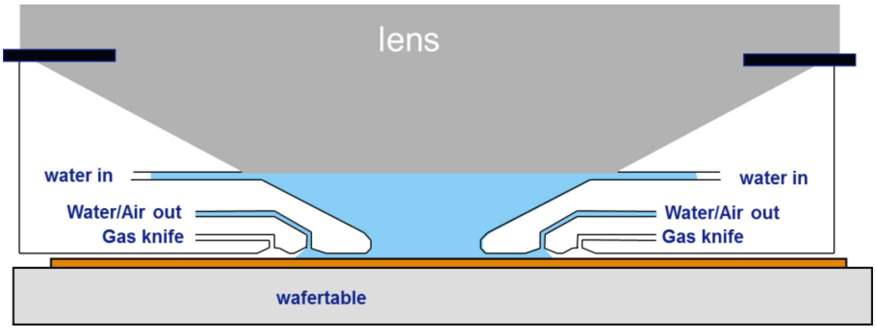

Fig. 1, Schematic cross section of a so called "immersion hood" as used in an immersion exposure system. The diameter of the immersion hood is app. 100 mm. The "flying height" above the wafer varies between 100 – 300 μm

The scan velocity of the wafer table should be maximized to increase productivity without creating defects on the substrate by lost droplets. This is limited by the applied photo resist coating and the flow conditions near the liquid-gas interface. ASML has extensively studied the dynamic behavior of moving contact lines for a variety of different photo resists and top coats, characterized by their static receding contact angle. Based on theories developed in the past [2,3,4,6], it was expected that the critical velocity would scale with the cube of the static receding contact angle (SRCA), as described by e.g. the "Cox-Voinov" relation, based on the hydrodynamics of the viscous flow in the receding tail (Fig.2).

Fig. 2, HS-image of a cross sectional view of a receding tail at high scan velocity.

However, in practice it turns out that the geometrical pre-factor in this relation, strongly depends on the coating-fluid interaction properties. This supports the theory that dynamics of dewetting is not only determined by hydrodynamics, but also by an effect that can be indicated as contact line friction [5]. Especially with low viscosity fluids, like e.g. water, the contact line friction could be dominant. Increasing the viscosity reduces the effect of contact line friction, but even in the limit the pre-factor of water/glycerol mixtures is almost a factor two higher than the expected geometrical pre-factor. Similar experiments with silicon oils of various viscosity showed values close to the theory [4], which indicates that besides viscosity other fluid properties as e.g. polarity might have a substantial effect. Experimental results are presented for a number of fluids.

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