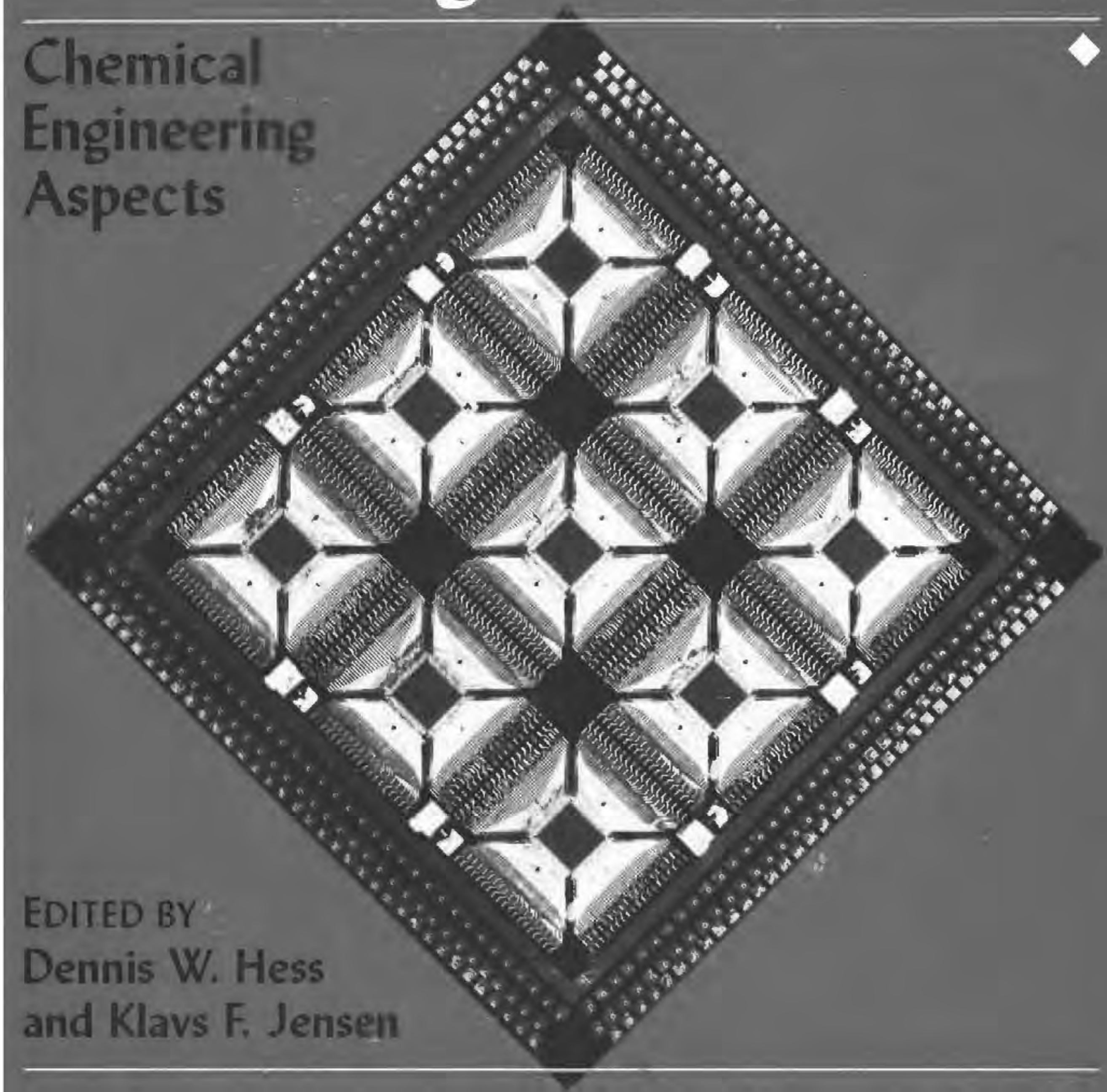
Microelectronics Processing

Chemical Engineering Aspects



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Resist Stripping. After the additive or subtractive processes of the substrate are complete, the resist mask must be completely removed by either wet or dry etching. The selection of resist stripper is determined by previous resist history (bakes, exposure to plasma, etc.) that results in chemical alteration and by the underlying substrate stability (*176*). Wet etches are either solvent-based or inorganic reagents such as H_2SO_4, HNO_3 or H_2O_2. Solvent-type strippers are typically acetone for positive resists, trichloroethylene for negative resists, or commercial products developed to remove both types of resists. Commercial organic strippers were initially phenol-based solvents but have been manufactured recently with little or no phenol as a result of health and safety issues associated with the use of this chemical. Plasma stripping or ashing of resist with either O_2 or O_2–CF_4 gases is clearly the method of choice from the standpoint of convenience, cost, and safety. However, the method cannot be used with substrates that are etched by these plasmas.

Auxiliary Process Steps. In addition to the standard process steps, auxiliary processes are sometimes necessary. These steps are not used for all situations but as required and will be considered in this section separately. Certain semiconductor-manufacturing processes are particularly damaging to polymeric films and require an additional step to harden the resist. For example, Al etching with chlorine plasma produces $AlCl_3$, which degrades resists. Ion implantation, in which the chamber temperature and, hence, the wafer temperature increase with increasing implant dose, causes thermal deformation of the resist image. One commonly used method to stabilize novolac-based resists is deep-UV flood exposure after patterning (*177*). With deep-UV exposure, cross-linking of the polymer surface produces a film with increased thermal resistance. With this procedure, positive resists can withstand a 180 °C bake for 30 min. Fluorocarbon plasma treatment also stabilizes resists (*178*), because fluorine insertion impedes subsequent oxidation of the polymers.

As discussed previously, an optional postexposure, predevelopment bake can reduce problems with the standing-wave effect in DNQ–novolac positive resists. However, such a postexposure bake step is indispensable in the image reversal of positive resists (*37–41*) and certain resists based on chemical amplification of a photogenerated catalyst (*64–67, 77, 78*). For both types of resists, the chemistry that differentiates between exposed and unexposed areas does not occur solely during irradiation. Instead, differentiation occurs predominantly during a subsequent bake. Therefore, to obtain acceptable CD control in these systems, the bake conditions must be carefully optimized and monitored.

Rework. Masking steps frequently have the advantage over other IC-manufacturing processes of being able to undergo wafer rework. Rework

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