Microlithographic Layers

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Abstract. Microlithography is a highly precise pattern-transfer technique, needed for the manufacturing of semiconductor devices. In the microlithographic process, the image of a mask is transferred to a light-sensitive polymer film, a so-called photoresist. Photoresists consist of light-sensitive organic polymers, which are able to resolve submicrometer patterns. They are highly specified materials, having well-defined physical and mechanical properties, and are mainly composed of a linear organic polymer, a photoacid generator, and a solvent.

1. Introduction

There has been a steady trend towards an ever increasing miniaturization and performance gain of electronic devices during the last two decades, which seems to continue until the end of this century, at least. The integrated circuit (IC) is located in the centerpoint of this development. Since the complexity of ICs is steadily increasing, new applications for semiconductor devices are becoming possible. This gain in performance of IC devices is made possible by densifying the network of active functions (transistors, diodes) on the same piece of monocrystalline silicon (chip).

Whereas in 1965, a maximal amount of 250 electronic functions could be mounted on a silicon chip with the size of a fingernail (1 cm²), this number rose during the eighties to more than a million. Today, state-of-the-art devices can house up to 100 millions of electronic functions. It is believed that memory devices with the ability to store 1 Gbit of information, or even more, will turn into reality at the beginning of the next century. The area of a chip has not been changed a lot along the evolutionary pathway and has stayed at about fingernail size. However, the size of the active components of a chip has decreased from 20 μm (1 micron = 1 μm = 10⁻⁶ m) in 1963 to 2 μm in 1983 and lies currently at around 1/3 μm (≈ 330 nm = 3300 Å).

The three-dimensional electronic functions of an active IC device are manufactured by a sequence of lithographic steps. This reproductive technique is called microlithography and allows for the highly precise transfer of submicron patterns from a mask to a light-sensitive polymer film, a resist [1][2]. It is not easy to visualize the smallness of submicron dimensions, but microlithography would allow for the generation of dozens of ordered structures on the dimension of a human hair with a diameter of 50 μm. The pattern of the structured resist is finally transferred by etching methods to the underlying semiconductor substrate. For the build-up of a working IC device, this microlithographic pattern transfer process has to be repeated up to twenty times.

2. Resist Materials

Typically, a modern photoresist is composed of a linear organic polymer, a substance which generates strong Brønsted acid upon irradiation, and a solvent. Resist films of ca. 1 μm thickness are obtained by spin-coating of the photoresist solution onto the semiconductor substrate (wafer), followed by evaporation of the solvent. The reaction sequence outlined in the Scheme is involved in the image-forming process: in a first step A, acid is formed in the irradiated zones of the resist film. In a second step B, the acid initiates polymer degradation, and a resist pattern can be obtained.

Scheme. Reaction Sequence Involved in the Image-Forming Process of a Chemically Amplified Resist

Fig. 1. Maleimide-based resist polymer
Colored Systems with Improved Weatherfastness

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Abstract. Weatherfastness of pigmented organic coatings is a classical problem in the industrial world. We describe the photoreactivity of some heterocyclic pigments from the 1,4-dioxopyrrolo[3,4-c]pyrrole (DPP) family in suspension and in a polymer matrix, and the discovery of the photostabilization of organic crystals by nitroxy radicals.

1. Introduction

Pigments are finely divided, organic or inorganic, crystalline solids. They are used mainly for the coloration of polymeric materials like surface coatings (paints), plastics, synthetic fibers, and printing inks [1]. Contrary to dyeing, the coloration is obtained by dispersion of the microcrystals (0.01–1 μm) without dissolution of the chromophore molecules. Colored materials are made by purpose to absorb light, and it has been estimated that half of the annual production of polymers is employed outdoors [2]. Light stability is then a crucial property, because the consumer’s interest is in having articles with long life expectancies. For example, the shade of an automotive coating has to be stable for more than four years. For the manufacturer, this means bringing systems onto the market which have better light and weather stability.

Photodegradation of systems containing inorganic pigments like TiO2 is well documented [3]. However, the diversity of the photochemical processes underlying the degradation of organic pigments renders the field difficult and the literature covering the subject is scarce. Nevertheless the Pigment Division of Ciba started in its research center at Marly a project on colored systems with improved light- and weatherfastness [4].

2. Description of the Problem

A colored system has two major components, the pigment and the polymeric material (Scheme). Both of them will absorb part of the incoming light and partic-

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