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RADIATION CHEMISTRY

Adhesion of Irradiated Diazoquinone–Novolac Photoresist Films to Single-Crystal Silicon

S. A. Vabishchevich[a], S. D. Brinkevich[b, *], N. V. Vabishchevich[a], D. I. Brinkevich[b], and V. S. Prosolovich[b]

[a] *Polotsk State University, Novopolotsk, 214400 Belarus*
[b] *Belarussian State University, Minsk, 220050 Belarus*
**e-mail: brinkevichsd@bsu.by*

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Abstract—In this work, the effect of γ-irradiation on the adhesion properties of FP9120 diazoquinone–novolac photoresist films deposited on single-crystal silicon wafers by centrifugation was studied using an indentation method. It was found that γ-irradiation led to a decrease in the specific peeling energy G of photoresist films on silicon. In this case, the IR spectra of the photoresist exhibited a decrease in the intensity of vibration bands due to the Si–O–C moiety, which is responsible for adhesion to silicon, in the course of γ-irradiation. The observed experimental results were explained taking into account the radiation-chemical and relaxation processes occurring both at the photoresist/silicon interface and in the bulk of the polymer film.

Keywords: diazoquinone–novolac photoresist, γ-irradiation, adhesion, silicon
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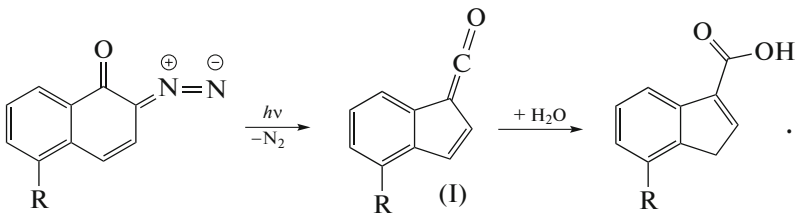
INTRODUCTION

Modern processes for the fabrication of electronic products are based on the use of photolithography (PL)—a method of forming a given pattern on a silicon substrate to obtain the required microcircuit topology [1]. The PL operations are repeated many times in the course of manufacturing a microcircuit on a plate. Thus, up to 10 photolithography operations are used in the formation of hardware components based on *n*-MOS technology, whereas about 22 PL operations are used in BiCMOS technology [2].

Resists—chemical substances or their mixtures that change their physicochemical properties under the influence of high-energy radiation (ultraviolet light, X-rays, and electron or ion beams)—are the materials used in lithographic processes. Positive two-component photoresists (PRs) based on photosensitive *o*-naphthoquinone diazide and a novolac resin base are most widely used in technological microelectronics processes. Under the influence of radiation with a wavelength λ of ~300–350 nm, *o*-naphthoquinone diazide in the photoresist film undergoes denitrogenation and then converts into 1-*H*-indene-3-carboxylic acid (reaction (1)) due to the presence of 1–2% water in the film. As a result of this photochemical process, the irradiated regions of the photoresist become soluble in a 0.1–0.3 M alkaline developer [1, 2].

The FP9120 positive photoresist, which is a composite of *o*-naphthoquinone diazide and a mixture of phenol– and cresol–formaldehyde resins, is widely used in modern semiconductor electronics as a protective photosensitive material in precision photolithographic processes for the manufacture of semiconductor devices and integrated circuits [2]. One of the most important technological characteristics of photoresist films is their adhesion to a single-crystal silicon substrate.



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