ANNEALING OF BORON-IMPLANTED SILICON BY A HEAT-ASSISTED NONCOHE--ETC(U)
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ANNEALING OF BORON-IMPLANTED SILICON BY A HEAT-ASSISTED NONCOHERENT LIGHT FLASH

H. A. Bomke
H. L. Berkowitz
M. Harmatz
S. Kronenberg
R. Lux

ELECTRONICS TECHNOLOGY & DEVICES LABORATORY

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**Title**: Annealing of Boron-Implanted Silicon by a Heat-Assisted Noncoherent Light Flash

**Authors**: H. A. Bemke, H. L. Berkowitz, M. Haimatz, S. Kronenberg, R. Lux

**Performing Organization Name and Address**: Electronic Materials Research Division, US Army Electronics Technology & Devices Laboratory (ERADCOM), Fort Monmouth, NJ 07703

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**Abstract**: High quality annealing of boron implanted silicon ($10^{15}$ cm$^{-2}$, 50 keV) was achieved using commercially available quartz xenon flash tubes after a 20 second preheat. Electrically active dopant profiles, obtained from spreading resistance profiles, indicate that the annealing proceeded by solid phase epitaxy. We also find that the degree of boron redistribution can be controlled by the cumulative exposure to the flash. Characteristics of the apparatus used suggest that annealing 3 inch diameter wafers with a throughput of 3 wafers per minute is feasible.
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1. (Top) Surface spreading resistance of annealed silicon versus distance measured perpendicular to the lamp in the sample plane. (Bottom) Energy fluence from a single flash versus distance measured perpendicular to the lamp in the sample plane using a 2 mm wide calorimeter.

2. Concentration of electronically active boron in silicon versus depth obtained from spreading resistance measurements in two annealed samples.
**INTRODUCTION**

Shortly after high speed annealing techniques came into use, several studies showed that flashlamps could be used to produce annealing of ion implanted semiconductor materials similar to that obtained using lasers or electron beams. However, these systems suffered many problems which made the application difficult to imagine. Among these were the small size of the annealed spot and damaging shock waves which shattered samples and lamps, to name just a few. Results obtained using a linear quartz lamp, together with those reported by Corruzzi and Pedulli, show that quartz flashlamp anneals with a pulselength of about 1 msec can be used for convenient initiation of reproducible solid phase epitaxial regrowth in silicon.

**DISCUSSION**

The lamp used in this work was a commercial linear quartz xenon lamp (Corruzzi FX-12). Its outer diameter is 0.9 cm and the gap distance 7.5 cm. With a 1.0 μF microfarad condenser battery and 400 microhenries in series, a non-oscillating current pulse of 0.9 msec FWHM was obtained. The silicon sample, 1 cm by 1 cm, was mounted on a flat heater spiral of low thermal mass and was placed at 1 mm distance from the flash tube (11 kV operating voltage). The light fluence was measured with a narrow strip calorimeter to be 25,00 joule/cm² at the closest approach to the lamp. The samples used for the annealing experiments were n-type 1 ohm-cm silicon implanted at room temperature with 10¹⁵/cm² 50 kev boron. The samples were brought from room temperature to 750 °C in 20 seconds at which time the lamp was flashed. Some samples were exposed to multiple annealing cycles, allowing samples to come to room temperature between cycles.

Samples were evaluated by two techniques of spreading resistance measurements: (1) surface measurements to determine the lateral uniformity and (2) depth profiling to determine the distribution of the boron after annealing. Figure 1 shows surface scans perpendicular to the lamp axis. The 2 mm wide low-resistance valley is indicative of the lateral extent of good annealing. Figure 2 shows a depth profile of the boron concentration measured in the low resistance valley. Comparison of the measured profiles with the LSS model as-implanted profile indicates modest boron redistribution during the anneal. In the multiply-exposed samples, no lateral growth of the annealed area was seen, while some spreading of the boron profile occurred. A narrow calorimeter was scanned laterally to measure the energy incident on the wafer surface with results shown at the bottom of Figure 1. The observed area of good annealing corresponds to an energy fluence of greater than 25 joule/cm². It can be seen that the output of 9 lamps in a closely packed array will produce the same energy fluence over a 3-inch wafer.

**ACKNOWLEDGEMENT**

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3. I. T. Lue, Appl. Phys. Lett. 36(1) 1 January 1980, 73.
Figure 1. (Top) Surface spreading resistance of annealed silicon versus distance measured perpendicular to the lamp in the sample plane. Samples were exposed 1 mm below the 9 mm diameter flashlamp. (Bottom) Energy fluence from a single flash versus distance measured perpendicular to the lamp in the sample plane using a 2 mm wide calorimeter.
Figure 2. Concentration of electronically active boron in silicon versus depth obtained from spreading resistance measurements in two annealed samples. The solid line is the implanted boron profile (Edgeworth distribution calculated from the LSS model, Reference 5).
