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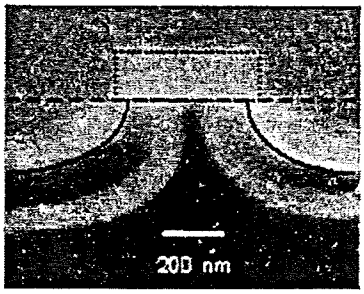

Continuing the tradition of excellence in bringing together scientists, engineers, and students for the sharing and strengthening of knowledge, research, and applications in semiconductor characterization and metrology that impact the dramatic progress in semiconductor technology and manufacturing.

New Developments in Deep Ultraviolet Laser Metrology for Photolithography†

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Abstract. Current and future laser measurement services at 157, 193 and 248 nm will be reviewed. Comparisons between NIST 193 and 248 nm primary standards will be presented; uncertainty assessments for DUV laser measurements will be discussed. Recent improvements in calibration procedures, leading to a reduction in overall uncertainties to the 1% level, will be presented.

INTRODUCTION

Increasing information technology requirements have yielded a strong demand for faster logic circuits and higher density memory chips. This demand has led to the introduction of deep ultraviolet (DUV) laser-based lithographic tools for semiconductor manufacturing. These tools, which employ KrF (248 nm) and ArF (193 nm) excimer lasers, have led to an increased demand for accurate laser measurements at the DUV laser wavelengths. As a result, the National Institute of Standards and Technology (NIST), with SEMATECH support, has developed primary standard calorimeters for both 193 nm and 248 nm excimer laser power and energy measurements.

UV LASER MEASUREMENTS

There are a number of laser measurements that are important for both tool development and performance. Laser power and energy measurements are used as part of a feedback mechanism to stabilize the source's pulse energy and to optimize laser dose at the wafer plane. Optical materials characterization measurements are used in tool design and modeling.

Laser Power and Energy

A diagram of the NIST DUV laser measurement system is shown in Figure 1. A pair of 193 nm primary standard calorimeters are used in conjunction with a specially designed calibration measurement system consisting of a nitrogen purged enclosure; a wedged, fused silica beamsplitter; and beam-shaping optics.

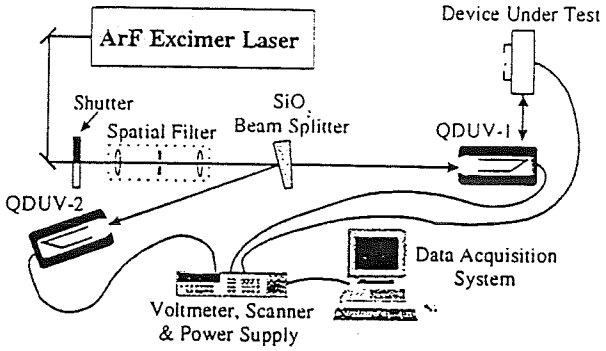

Figure 1. NIST UV measurement system for 193 nm laser power and energy measurements. QDUV-1 and QDUV-2 are the primary standard calorimeters. A 2° wedged, fused silica (SiO_2) beamsplitter is used for monitoring the power and providing attenuation.

Optical Materials Characterization

Optical material characterization measurements, such as transmittance and birefringence, are important for tool development and performance as well. Birefringence can be an inherent property of the material, or it can be introduced during the manufacturing process or by applying mechanical stress, such as clamping a mask. In particular, spatial variations across phase-shifting masks can lead to spatial variations across exposed wafers.

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Keywords: laser metrology, dose metrology, optical materials characterization