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A NEW INSTRUMENT FOR TENSILE TESTINGS OF THIN FREE STANDING FILMS AT HIGH STRAIN RATES

Eran Ben-David
Department of Mechanical Engineering, Technion,
Haifa 32000, Israel

Doron Shilo
Department of Mechanical Engineering, Technion,
Haifa 32000, Israel

Daniel Rittel
Department of Mechanical Engineering, Technion,
Haifa 32000, Israel

David Elata
Department of Mechanical Engineering,
Technion, Haifa 32000, Israel

ABSTRACT

The design of more reliable and sophisticated Micro Electro Mechanical Systems (MEMS) relies on the knowledge, understanding, and ability to control their mechanical response. In recent years, enormous progress has been made in developing new measurement techniques for studying the mechanical response of sub-micro scale specimens. However, there is still a lack of knowledge and testing techniques regarding the response of MEMS structures to mechanical shocks, which can appear during fabrication, deployment, or operation.

We present an instrument for testing the mechanical response of thin free standing films under uniaxial tensile stress at high strain rates of up to 2×103 sec-1. The experimental system consists of a micro-device, which contains the freestanding specimen, and an external system, which includes instrumentation for measuring its mechanical response. The components of the external system are controlled by a single interface, and allow for a variety of displacement profiles to be applied to the specimens. All the instrumentation operates at high sampling rates (above 1 MHz) to allow for high strain rate application.

The freestanding specimen is produced by MEMS fabrication techniques on a micro-device that also includes S-springs to protect the specimen and aluminum grating lines for measuring the displacement. One side of the chip is pulled by a piezoelectric translation stage, which allows controlling the displacement with a nanometric resolution and applying high velocities and accelerations. The specimen displacement is monitored by an optical encoder device that measure the displacement of the aluminum grating located on the micro-device close to the specimen with an accuracy of about 10 nm. The load is determined by measuring the charge on a piezoelectric PMN-30%PT shear plate, which is connected to the pin that holds the micro-device.

The new instrument is applied for studying the response of thin aluminum films with thickness of 0.5-1 μm, width that varies between 5 to 50 μm, and length of 120 μm. The mechanical response of these specimens is measured at different strain rates and is compared to measurement done by nanoindentation.