

# THE YOUNG'S MODULUS AND RESIDUAL STRESS OF TiN<sub>x</sub> THIN FILMS

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**Abstract:** *The bulge test was first conducted on the silicon nitride films to determine its proper residual stress and Young's modulus which were found to be  $\sigma_i = 228 \pm 15$  MPa and  $E = 226 \pm 10$  GPa, respectively. Finally, using a simple rule of mixture formula, the elastic mechanical properties of TiN<sub>x</sub> coatings were determined. Both the Young's modulus and residual stress showed increasing values with bias voltage, nitrogen to titanium ratio, and coating density. In contrast, the effect of substrate temperature below 900 °C was found to be less significant compared to other parameters. Scanning electron microscopy of cross sectioned samples showed that coating growth occurs by formation of equiaxial crystallites, which leads to columnar morphology beyond a thickness of 4 – 10 μm. The columns are nearly perpendicular to the film surface.*

**Keywords:** *keywords thin films, young's modulus, residual stress, columnar morphology*

## 1. Introduction

Titanium nitride coatings, because of high hardness, have been widely used in a variety of wear applications. Many investigations dealing with functional properties of coating or with relationships between mechanical properties and deposition parameters exist in the literature. However, fundamental study of coating growth, structure, and defects is desirable to more accurately describe the performance and reliability of thin films. Several experimental methods are available for measurement of mechanical properties films that been attached to the supporting substrate [1,2].

Among these techniques, the bulge test of free standing films was found to be a promising method for determination of in plane mechanical properties whereas the problems associated with specimen edge are eliminated. In this test, one applies a variable uniform pressure to one side of the film and measures the resulting deflection. As the pressure-deflection curve is a function of

sample geometry and thin film strength, the elastic mechanical properties such as residual stress and Young's modulus can be determined from the data.

Several experimental procedures have been used to fabricate free standing films and perform bulge tests experiments. The standard micromachining techniques develop in semiconductor industry were used to prepare free standing thin films with precise dimension and because of this fact the accuracy of the bulge test was significantly improved [3,4].

In spite of the great influence of Young's modulus and residual stress on adhesion and thermal shock resistance of titanium nitride thin film, the values given in the literature are scattered and cover relatively a wide range of variation probably due to the variable quality of the coatings. In this paper, mechanical behaviour of TiN<sub>x</sub> thin films deposited is considered and the preliminary results obtained at room temperature testing are presented together with methods used for preparation of samples. The variation of the