Designation: F 576 – 00

Standard Test Method for Measurement of Insulator Thickness and Refractive Index on Silicon Substrates by Ellipsometry [1]

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INTRODUCTION

When this test method was developed in the mid-1970's, manual-null ellipsometers, which are the basis of this test method, were in routine use. More recently, faster, automated instruments have replaced manual-null ellipsometers for all common use in the semiconductor industry. There are two basic types of such automated instruments commonly used: the rotating element null ellipsometer and the rotating element photometric ellipsometer. For each of these, microprocessors or microcomputers are used to operate the instrument and to analyze the data. Details of the procedures utilized in these instruments are usually considered to be proprietary by the instrument manufacturers.

Despite the fact that this test method is not commonly used in its present form, it embodies all the basic elements of this test method and a simple analysis of data. Thus, it provides useful guidance in the fundamentals and application of ellipsometry to film thickness measurements. Until a test method, or test methods, can be developed that cover the newer, automated instruments, this test method provides the only such information that is available in a standard test procedure. It also contains results of a test of interlaboratory precision on silicon dioxide films from 20 to 280 nm using manual null ellipsometers, and of a test of interlaboratory precision of films of 5 to 550 nm using both manual null ellipsometers as well as automated ellipsometers of both types just mentioned.

Two major changes have occurred since this test method was initially adopted. First, reference materials certified for the thickness of silicon dioxide layers on silicon are available both from the National Institute of Standards and Technology and from commercial sources. These can be used to evaluate the performance of automated ellipsometers. Second, significantly improved materials and procedures have been developed for storage of reference wafers needed for long term testing of baseline performance of ellipsometers. It is not uncommon for reference wafers simply to be stored "clean" with no further wafer-cleaning utilized. If cleaning steps are in fact, utilized, they are not those described in this test method. The cleaning steps detailed in this test method are retained, however, to provide background information on procedures used for the first of the interlaboratory tests.

1. Scope

1.1 This test method covers the measurement by ellipsometry of the thickness and refractive index of an insulator grown or deposited on a silicon substrate.

1.2 This test method uses monochromatic light.

1.3 This test method is nondestructive and may be used to measure the thickness and refractive index of any film not absorbing light at the measurement wavelength on any substrate (*1*) not transparent to light at the measurement wavelength, and (*2*) of a material for which both the refractive index and the absorption coefficient are known at the measurement wavelength.

1.4 The precision of this test method is reduced by variations, over regions smaller than the light-beam spot size, in substrate flatness, insulator thickness, and index of refraction.

1.5 Film thickness measurements determined by ellipsom etry are not unique. When the film thickness is greater than that calculated from the expression $N\lambda/[2(n^2 - \sin^2\phi_0)^{1/2}]$, where N is an integer, λ the measurement wavelength, n the index of refraction, and ϕ_0 the angle of incidence, the thickness value determined by this expression must be added to the thickness value determined by ellipsometry to obtain the correct film thickness. The value of N must be obtained by another procedure.

1.6 Two procedures for computing the results are provided. If the graphical procedure is used, the measuring wavelength shall be either 546.1 or 632.8 nm, and the angle of incidence shall be 70 ± 0.1°.

1.7 This test method may be used for referee measurements

[1] This test method is under the jurisdiction of ASTM Committee F01 on Electronics and is the direct responsibility of Subcommittee F01.06 on Electrical and Optical Measurements.

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