

**Variable Angle Reflectance and Transmittance of Thin Film Coatings Using the Shimadzu SolidSpec-3700 and UV-3600 Plus UV-Vis-NIR Spectrophotometers**

■ Introduction

Thin films (10  $\mu\text{m}$  and less total thickness) are a big business and can be found in almost all modern products. Thicker “protection” films or “hard coats” are found on a wide array of consumer products including such items as door knobs, automotive wheels, and eye glass lenses. These thicker films are designed to offer a protection layer that resists scratching of the underlying surface as well as offering a barrier to moisture and other deleterious compounds. Thinner films are also found in almost all food packaging materials, which can be composed of a number of thin film layers, each of which provides a specific function, such as moisture, UV, or oxygen barrier or surfaces suitable for ink adhesion and protection. Anti-reflective (AR) coatings can consist of one to many thin film layered stacks and are also found on many consumer products including eye glass lenses, camera lenses, binoculars, display screens, cell phones, and solar cells to name just a few.

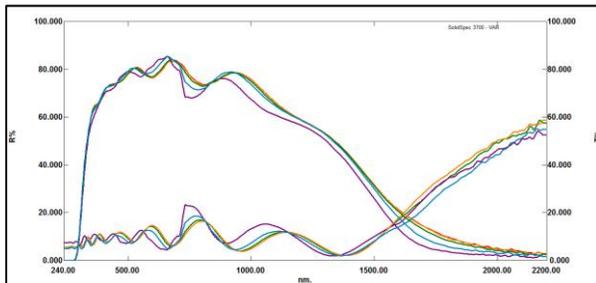
The vast majority of these films must allow light transmission, yet still provide the physical or optical function that they were designed to achieve. The film’s functional characteristic is intimately related to its thickness. AR stacks, for example, can be made up of twelve layers of alternating high and low refractive index materials ranging in thicknesses from

10 nm to 150 nm. Control of such thickness in production and QA/QC of products can be a challenging endeavor.

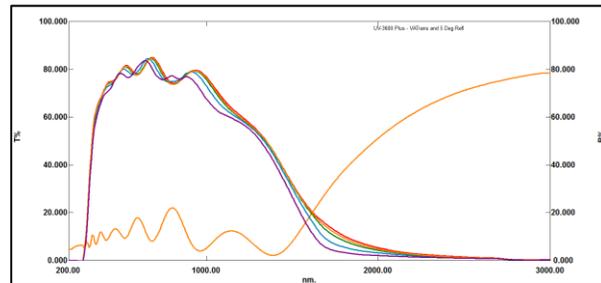
The ability to easily characterize films by variable angle transmission and reflection is very important in both the design/development process and in the final production. Shimadzu offers two UV-Vis-NIR Spectrophotometers and a variety of accessories that are well-suited for these tasks. Specifically, the SolidSpec-3700 equipped with the Absolute Variable Angle Measurement Attachment (VAMA), and the UV-3600Plus equipped with the Variable Incident Angle Film Holder (VIAFH) and the 5-Degree Specular Reflectance stage. Both spectrophotometers and accessories can characterize films in the full spectral wavelength region, extending from the UV, through the Visible, and well into the Near Infrared.

■ Experimental Data

Below is characterized four thin film depositions on 25 x 25 mm glass substrates. Transmission is measured in both spectrophotometer instruments at angles of incidence of 0, 5, 15, 30 and 45 degrees. Reflection is measured at the same angles of incidence in the SolidSpec-3700 and at a 5-degree angle of incidence on the UV-3600 Plus. The acquired spectral acquisitions are shown below.

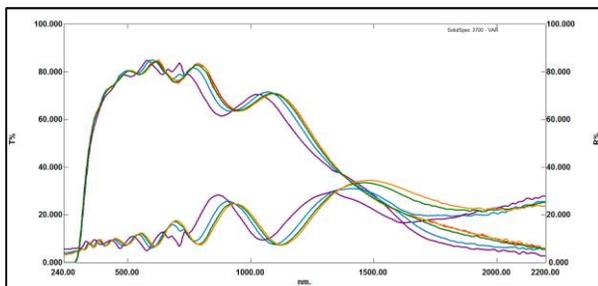


SolidSpec-3700 – VAMA



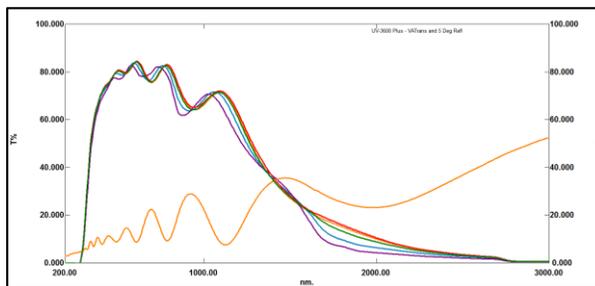
UV-3600 Plus – VIAFH and 5-Deg SR

Sample 1 - 0 Deg (red), 5 Deg (orange), 15 Deg (green), 30 Deg (Blue), and 45 Deg (violet)

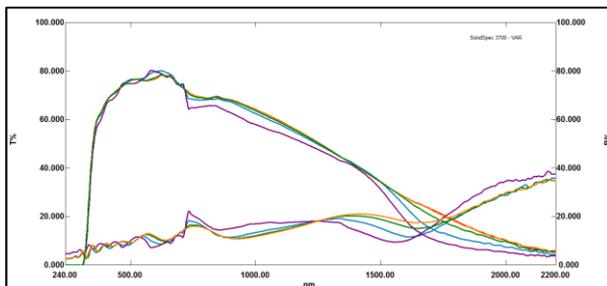


*SolidSpec-3700 – VAMA*

Sample 2 - 0 Deg (red), 5 Deg (orange), 15 Deg (green), 30 Deg (Blue), and 45 Deg (violet)

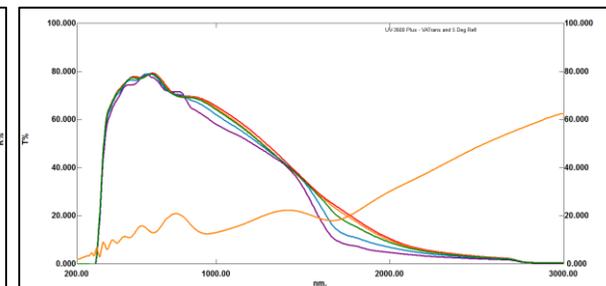


*UV-3600 Plus – VIAFH and 5-Deg SR*

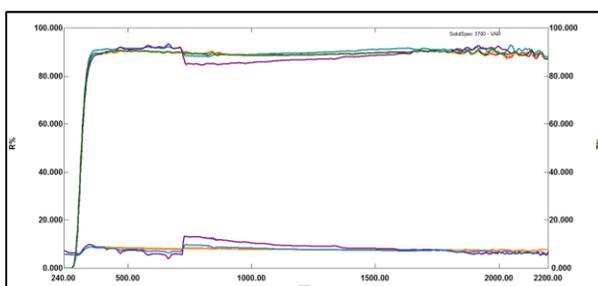


*SolidSpec-3700 – VAMA*

Sample 3 - 0 Deg (red), 5 Deg (orange), 15 Deg (green), 30 Deg (Blue), and 45 Deg (violet)

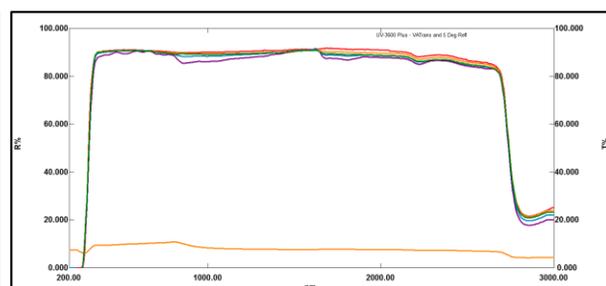


*UV-3600 Plus – VIAFH and 5-Deg SR*



*SolidSpec-3700 – VAMA*

Sample 4 - 0 Deg (red), 5 Deg (orange), 15 Deg (green), 30 Deg (Blue), and 45 Deg (violet)



*UV-3600 Plus – VIAFH and 5-Deg SR*

## ■ Results

The spectra above show good correlation between spectral acquisitions on the two spectrophotometer systems and accessories. The advantage of the SolidSpec-3700 and VAR accessory is the need to acquire only one baseline, which can be used for any Transmittance and Reflectance angle; this saves time and cost in analysis. In addition, the reflection spectra obtained with the SolidSpec-3700 are absolute in nature. The UV-3600 Plus has the same monochromator and 3-detector design as the SolidSpec-3700, which provides superior noise

reduction and higher resolution for the full spectral wavelength range. The UV-3600 Plus does not incorporate an integrating sphere in the detector system, allowing for an extended analytical range to 3300 nm with optimum S/N.

## ■ Conclusion

Both the SolidSpec-3700 and UV-3600 Plus spectrophotometers are rock-solid system that provide features ideal for thin film characterization in both R&D and Production environments.



SHIMADZU Corporation  
www.shimadzu.com/an/

SHIMADZU SCIENTIFIC INSTRUMENTS  
7102 Riverwood Drive, Columbia, MD 21046, USA  
Phone: 800-477-1227/410-381-1227, Fax: 410-381-1222  
URL: www.ssi.shimadzu.com

First Edition: January 2016

For Research Use Only. Not for use in diagnostic procedures.  
The contents of this publication are provided to you "as is" without warranty of any kind, and are subject to change without notice.  
Shimadzu does not assume any responsibility or liability for any damage, whether direct or indirect, relating to the use of this publication.