Synchrotron Radiation X-ray Diffraction and Spectroscopic Ellipsometry Investigation of Si_3N_4 on Si for Sub-Micro Si-IC Applications

Li-Chi Cheng (鄭立琦)[1], Chu-Wan Huang (黃初旺)[1], Zhe-Chuan Feng (馮哲川)[1], Ying-Lang Wang (王玉郎)[2], and Hwo-Shuenn Sheu (許火順)[3]

[1]Graduate Institute of Electro-Optical Engineering and Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan
[2]Taiwan Semiconductor Manufacturing Company, Tainan, Taiwan
[3]National Synchrotron Radiation Research Center, Hsinchu, Taiwan

The experimental result of VASE was shown in Figure 1, which is fitted using Cauchy model with thickness of 50 nm on the top and 1 mm Si substrate on the bottom.

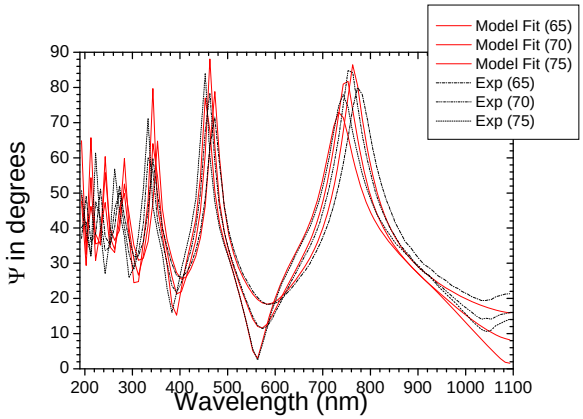

Figure 1. *Experimental and model fitting for a 50nm Si_3N_4 on Si, and the thickness was adjusted to fit the 75° data.*

Figure 2 shows the Synchrotron X-ray diffraction (SR-XRD, λ~ 0.443Å) patterns recorded at room temperature for the 50nm Si_3N_4 thin film grown on the Si substrate by CVD method. Figure 3 shows an ordinary X-ray diffraction (XRD, 1.54Å) pattern for the same sample, i.e. 50 nm thick Si_3N_4 thin film grown on the Si substrate, labeled accordingly. The mainly observed peak positions are listed in the table. In Figure 6, the index of Si_3N_4 is diminished from 1.54 into 1.50 gradually when the wavelength changes from 400 nm to 1100 nm, and is smaller than pure Si_3N_4 (~ 2).

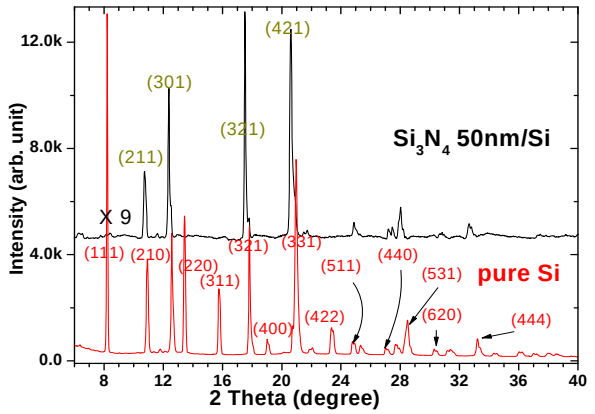

Figure 2. *Synchrotron X-ray diffraction (SR-XRD, λ~ 0.443Å) patterns for the 50nm Si_3N_4 thin film grown on Si and a bare Si substrate.*

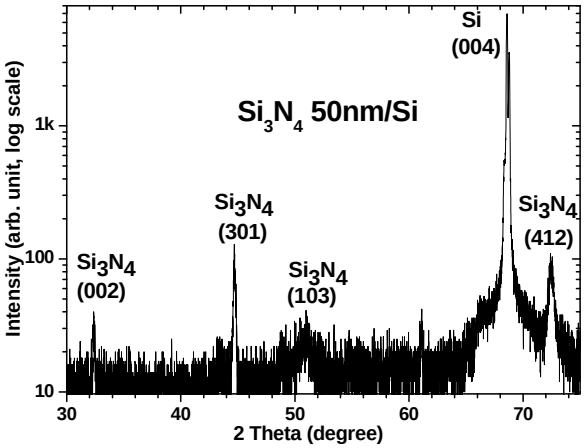

Figure 3. *Ordinary X-ray diffraction (XRD, 1.54Å) patterns for the 50 nm Si_3N_4 thin film grown on the Si substrate.*

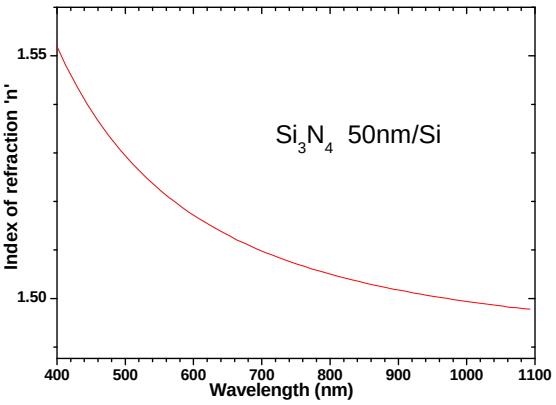

Figure 6. *The Si_3N_4 refractive index variation from 1.55 to 1.50 in the wavelength range of 400-1100 nm.*

We have performed systematic and preliminary study on Si_3N_4 thin film grown on 12" silicon wafer, including synchrotron radiation X-ray diffraction and variable angle spectroscopic ellipsomemter. By the using of superior experimental instruments, we found that there is a mixture state of α- and β- Si_3N_4 and other impurities present in the samples and index become smaller than pure Si_3N_4. We are going to plan another set of synchrotron XRD measurements using 1.0 Å (12 KeV) synchrotron source. So we will have three wavelengths (0.442806, 1.0 and 1.54 Å) excitation XRD data on the samples. This will benefit to analyze the studied materials and lead to better understand materials properties.