220e Mechanical Strength Measurements of Single Crystal Zeolites Cha, Mfi, and Fer by Nanoindentation

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Zeolites have found various commercial uses in the catalysis, adsorption, and ion exchange industries. As such, the mechanical properties of zeolites have not been well studied. However, as zeolites find more uses in other areas, strength and hardness are becoming critical parameters. For example, pure-silica zeolites are a strong candidate for a replacement low-dielectric constant (low-k) material for next-generation microprocessors. In order to survive the chemical-mechanical processing steps, the semiconductor industry generally acknowledges a minimum threshold value of 6 GPa for these materials. Both amorphous porous silicas and zeolites have been proposed as low-k alternatives, and we hypothesize that the highly ordered and highly crystalline nature of zeolites will result in a higher mechanical strength than the amorphous silicas.[1] The mechanical properties have previously been measured for zeolite thin films, and the strength and hardness of single zeolite crystals will further the understanding of the high mechanical strength of the films.[2] We report for the first time elastic modulus and hardness values by nanoindentation for single zeolite crystals with CHA, MFI, and FER-type structures. Multiple-load displacement curves resulted in consistent data points, and the elastic moduli for the crystals ranged from 40 to 50 GPa and the hardness was 6 to 8 GPa. These values were consistently higher than amorphous silicas of comparable porosities.

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[1] Wang, Z.B.; Wang, H.T.; Mitra, A.P.; Huang, L.M.; Yan, Y. *Adv. Mater.* **2001**, *13*, 746-749.

[2] Wang, Z.B.; Mitra, A.P.; Wang, H.T.; Huang, L.M.;Yan, Y.S. *Adv. Mater.* **2001**, *13*, 1463-1466.