Spacing effect on dislocation injection from sharp features in strained silicon structures

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In practice, the SiN stripes or pads are periodically patterned on silicon, so the spacing effect on dislocation injection from sharp features deserves attention. As in Figure 1, the SiN stripes with residue stress σ, of width L and thickness h, are periodically patterned with spacing S. In the numerical calculation, we take shear modulus and Poisson's ratio of Si_3N_4 to be 54.3 GPa and 0.27, and those of silicon 68.1GPa and 0.22, the same as in Ref.[1].

Consider one of the corners, the stress field around the corner root is singular and takes the form

$$\sigma_{ij}(r,\theta) = \frac{k}{(2\pi r)^\lambda} \Sigma_{ij}(\theta).$$

(1)

The stress intensity factor, k, should take the form

$$k = \sigma h^\lambda f(L/h, S/h).$$

(2)

where $\lambda = 0.4514$. The dimensionless function $f(L/h, S/h)$ is determined by using a finite element method. We calculate the full stress field in the structure by using the finite element package ABAQUS, then fit the interfacial shear stress close to the root, say $10^{-3} < r/h < 10^{-2}$, to the equation $\sigma_{r\theta} = k/(2\pi r)^\lambda$, with k as the fitting parameter.

The resulting value of $f(L/h, S/h) = k/(\sigma h^\lambda)$ is plotted in Figure 2 as a function of the ratio of spacing to thickness of the stripe for different aspect ratios L/h=2 and 20. The effect of

spacing is quite small for both the large stripe pattern (*L/h*=20) and the small one (*L/h*=2), except that the spacing becomes too small, say $S \leq h$. But the effect of aspect ratio (*L/h*) is quite obvious, as shown by the difference between two curves in Figure 2, which is consistent with the conclusion in Ref.[1].

References:

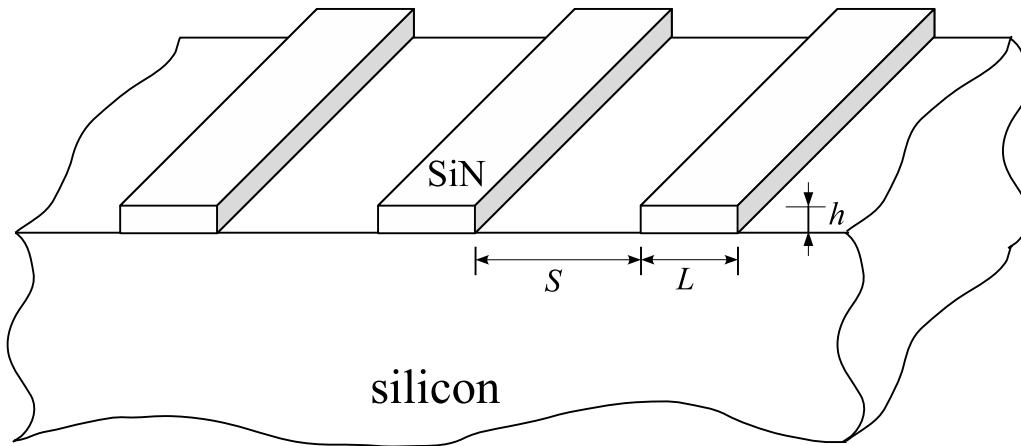1. Z. Zhang, J Yoon, and Z. Suo, APL **89** *in press* (2006). Preprint is available on http://imechanica.org/node/434 .

FIG. 1. The SiN film, of thickness *h* and residual stress σ, is grown on the (001) surface of a single-crystal silicon substrate. The film is then periodically patterned into stripes of width *L* and spacing *S*, with the side surfaces parallel to the (110) plane of silicon.
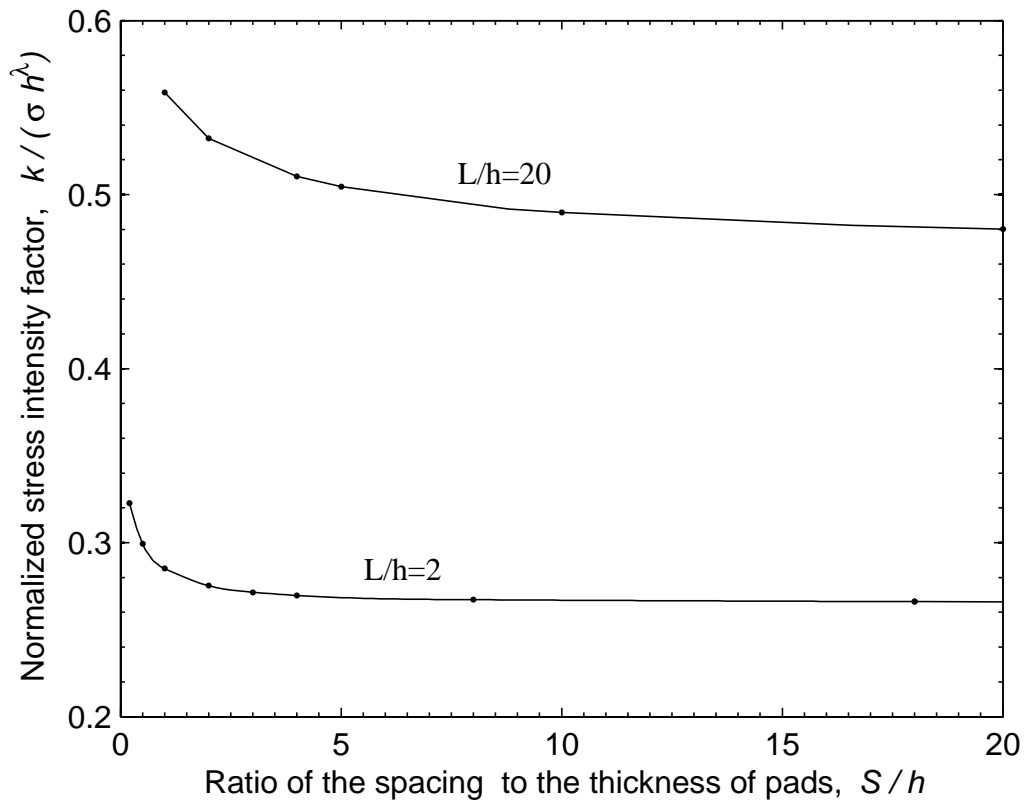
FIG. 2. The normalized stress intensity factor, $f(L/h, S/h) = k/(\sigma h^{\lambda})$, is shown as a function of the ratio of spacing to thickness, S/h, of the nitride stripe.