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This Week's Citation Classic

Grove A S, Deal B E, Snow E H & Sah C T. Investigation of thermally oxidized silicon surfaces using metal-oxide-semiconductor structures. *Solid-Stale Electron.* **8**:145-63, 1965. [Fairchild Semiconductor Division of Fairchild Camera and Instrument Corp.,,Palo Alto, CA]

The results of a comprehensive study of the overall electrical characteristics of thermally oxidized silicon surfaces show that the charge in the surface states is constant over a wide range of variation of the surface potential, and that this charge is positive for both *n* and *p*-type oxidized silicon. The density of surface state charge is about $2x10^{11}$ cm^{-2}, and is essentially unaffected by a 20-fold variation in the oxide thickness and by a 250-fold variation in the concentration of boron in the *p*-type samples. [The *SCI*® indicates that this paper has been cited over 260 times since 1965.]

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"All of us—Bruce Deal, Ed Snow, C.T. Sah, and myself—were extremely pleased to find that our 1965 paper has become a 'Citation Classic' It is gratifying, and particularly so, because at the time the paper was written it was by no means obvious that it would ever become a classic of any sort. In fact, we had quite a difficult time just having it accepted for publication. As I remember, one reviewer found the paper was 'too obvious,' and recommended against its being published. This in turn was in strong conflict with the experience we gained when I presented this very paper in oral form in the summer of 1964 at the IEEE Solid State Device Research Conference.

"At that point, the workers in the field were struggling with highly unstable surfaces due to insufficiently annealed interfaces and to terribly contaminated oxide layers. They were puzzled by the random and non-reproducible results, which along the lines of the then-prevailing thinking they interpreted as being due to large numbers of surface states whose characteristics and numbers varied as a result of differences in preparation techniques, temperatures, biasing history, and whatever else.

"Our group by this time had managed to figure ways of preparing samples with stabilizing surface characteristics, and at the conference we were the only ones presenting results based on such samples. (In another year or two, the entire scientific community mastered similar techniques, and a few years after that a major new industry took off, based on a variety of surface stabilization techniques. This industry —the metal oxide semiconductor (MOS) large scale integration (LSI) industry —is of a billion dollar annual size today!)

"But in 1964, all of this was new and unique —so much so that at the conference I distinctly felt that people believed either that we didn't know what we were doing, or that we were cheating. I remember the dead silence that followed my presentation, the absence of questions, and the empty sinking feeling we shared that the majority of the audience thought we were fools.

"However, we turned out to have been right, and our work in fact became a major element of the MOS device research which has subsequently been followed by developments in the semiconductor memory and microprocessor fields."