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Goldsmith N & Kern W. The deposition of vitreous silicon dioxide films from silane. *RCA Rev.* **28**:153-65, 1967.
[RCA Electronic Components and Devices Division, Somerville, and RCA Laboratories, Princeton, NJ]

The oxidation of silane at 250 to 550°C is used to produce uniform films of silicon dioxide suitable for use in fabricating solid-state devices. The equipment and deposition parameters are described as are the properties of the films. [The *SCI*® indicates that this paper has been cited in over 90 publications since 1967.]

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"The original impetus for this work was the search for a method for passivating the surface of GaAs diodes. We speculated that SiO_2, which served so well on silicon surfaces, would perform similarly on GaAs. Since low temperature deposition was important, we decided to use silane as the source gas despite fears that the reaction would be hard to control because of the high reactivity of silane.

"Our first equipment, set up in 1964, consisted of a quartz tube narrowed at one end to form a jet. Nitrogen-diluted silane was directed toward a GaAs wafer which was resting, in air, on a hot plate. Despite our best efforts we could not obtain uniform deposition over areas larger than a few mm^2. That was sufficient to coat many diodes, but was hardly suitable as a production process.

"I then turned a fritted Buchner funnel upside down to form a reaction chamber resting on a hot plate. Silane, diluted with nitrogen, was introduced above the frit and mixed with oxygen below the frit. Deposition now occurred over a much larger area but was still not uniform. I finally obtained uniform deposition by adding a rotating platen and slotting the lip of the funnel to control the exhaust.

"The success of this modest piece of experimental equipment was overwhelming. I compiled a three-page list of applications for the films. Copies of the equipment, even though it was barely characterized, were prepared for use in the *production* of silicon devices. (J. DiPiazza and I gathered the data published for the 'experimental' reactor in one frantic week.) The scaled-up reactors, with planetary substrate rotation and optimized gas flow geometry, were developed by my coauthor, W. Kern. A surprising result of our studies was the finding that the optimum oxygen to silane ratio was higher than that required by stochiometry, especially at the higher temperatures, but that excess oxygen inhibited the reaction.

"In the years since the original work, the basic method has been expanded to permit the deposition of binary and ternary silicate glasses by adding other hydrides, such as diborane and phosphine, to the gas stream.[1-3] This allows the formation of films with specialized properties such as lowered softening temperature or a gettering ability for alkali ions. Production equipment to deposit these films is now commercially available.

"I think that several reasons account for the citation frequency of this work. Deposited oxides derived from the oxidation of silane are essential to the fabrication of virtually every solid-state device or circuit made today. As a result, the preparation and properties of these films have been the object of many studies. I also believe that our brief paper set a *de facto* standard for the data and analysis needed to characterize a system. Lastly, I have to point out that Kern has continued to explore silane-derived deposited films and their properties.[4-5] He is internationally known and honored for such work." [See: Kern W. Citation Classic. Commentary on *RCA Rev.* 31:187-206, 1970. *Current Contents/Engineering, Technology & Applied Sciences* 14(11):18, 14 March 1983.]

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1. **Kern W.** *Silicate glass coating of semiconductor devices.* US patent 3,481,781. 2 December 1969.
2. **Kern W & Helm C H.** Chemical vapor deposition of silicate glasses for use with silicon devices. I. Deposition techniques. *J. Electrochem. Soc.* **117**:562-8, 1970.
3. ----------------------------. Chemical vapor deposition of silicate glasses for use with silicon devices. II. Film properties. *J. Electrochem. Soc.* **117**:568-73, 1970.
4. **Kern W & Ban V S.** Chemical vapor deposition of inorganic thin films. (Vossen J L & Kern W, eds.) *Thin film processes.* New York: Academic Press, 1978. p. 257-331.
5. **Kern W & Schnable G L.** Chemically vapor-deposited borophosphosilicate glasses for silicon device applications. *RCA Rev.* **43**:423-57, 1982.