This Week's Citation Classic

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Sigmund P. Theory of sputtering. I. Sputtering yield of amorphous and polycrystalline targets. *Phys. Rev.* **184**:383-416, 1969.
[Metallurgy Division, Argonne National Laboratory, Argonne, IL]

Sputtering is the erosion of solid surfaces by particle bombardment.[1] The paper presents a theoretical evaluation of sputtering yields resulting from atomic collision cascades on the basis of linear transport theory for a wide variety of irradiation conditions. [The *SCI*® indicates that this paper has been cited in over 670 publications since 1969.]

Peter Sigmund
Fysisk Institut
Odense Universitet
5230 Odense M
Denmark

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"In June 1964, I attended an international summer school on atomic collisions in solids at Strandkrogen, Fakse Ladeplads, Denmark. It was a small school, but the best I ever attended: Hans Henrik Andersen and I made up the organizing committee, the lecturers, and the audience. One of the topics we learned a lot about was Silsbee focusons, i.e., collision chains propagating along crystal lattice rows. They seemed important in radiation damage, but their verification was drawn from ejection patterns in sputtering experiments.

"Following a suggestion by Jens Lindhard, I had a closer look at the sputtering literature. Theoretical work with Christian Lehmann at Jülich revealed that surprisingly little had been learned about focusons from sputtering experiments.[2]

"Our paper was received with significant disbelief. During my visit to Amsterdam, Jaap Kistemaker expressed doubts as to whether we could account for measured sputtering rates without invoking long-range mass transport. Obviously, a transport calculation had to be done to predict sputtering rates from first principles.

"From Lindhard and his group, and from several others, I had learned a lot about the slowing down of atoms in solids,[3] and a long cold winter at Argonne National Laboratory gave me time and patience enough to go through the whole thing.

"One significant reward came right after my talk at a Gordon conference in 1968 where I reported on my findings: I was offered a big Dutch cigar by Kistemaker. I had never tried one before, but survived.

"I had a suspicion that my work was going to be useful, although hardly anybody at the time could anticipate the wealth of applications of sputtering phenomena that since have come up in microelectronics, surface analysis, and astrophysics, to mention just three. Anyhow, I spent an extra winter trying to generate a decent write-up. I wanted to include everything an experimentalist would need to generate useful numbers. In addition, I aimed at optimal documentation. This strategy was apparently appropriate. I have since written papers which, I think, were more clever, but where I left it up to the readers to extract results and to draw some of the conclusions. Perhaps I should not have done that.

"The paper got a bit long, so I found it necessary to divide it into three parts. Only Part I ever got finished. I am still keeping all the request cards that I received for Parts II and III, for possible future use. While the paper went smoothly through the reviewing process, it went even too smoothly through the printing. In fact, I never received proofs. Thanks to professional printers and to a carefully typed manuscript, the number of essential printing errors on 34 pages turned out to be minimal."

1. **Behrisch R.** ed. *Sputtering by particle bombardment I. Physical sputtering by single-element solids.* Berlin: Springer-Verlag, 1981. 281 p.
2. **Lehmann C & Sigmund P.** On the mechanism of sputtering. *Phys. Status Solidi* **16**:507-11, 1966.
3. **Sigmund P.** LSS and the integral equations of transport theory. *Phys. Scr.* In press, 1983.