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Cho A Y & Arthur J R. Molecular beam epitaxy.
Prog. Solid State Chem. **10**:157-91, 1975.
[Bell Laboratories, Murray Hill, NJ]

The technique and procedure for epitaxial growth of III-V compounds of molecular beam epitaxy (MBE) is described. The unique feature of MBE is the control of film thickness and compositional profiles. A reproducible thickness control of 5Å is achieved during the growth of superlattice structures. [The *SCI*® indicates that this paper has been cited in over 390 publications since 1975.]

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The request by the Institute for Scientific Information® to write a commentary for *Citation Classics* about the article "Molecular beam epitaxy," which was published in *Progress in Solid-State Chemistry*, led me to ponder why some of my papers have been cited more often than others. In general, authors prefer to reference their own work because it is what they are most familiar with. In order to be referenced, a paper should include useful information such as numbers, equations, and experimental procedures. Most importantly, it should be *first* in the field.

In 1974 when we were asked to write the review article on molecular beam epitaxy (MBE), we decided to describe the technology from its inception to the state-of-the-art results. We included all the published articles on this subject and listed them in chronological order at the end of the paper. This was still possible then, but it would be impossible in 1985.

The circumstances prompting our research are unique. After I finished my PhD dissertation on the subject of adsorption and desorption studies of silver and gold atoms on tungsten surfaces, I joined Bell Laboratories, Murray Hill, New Jersey, in 1968. At that time, John Arthur was studying adsorption and desorption kinetics of Ga and As atoms on GaAs surfaces. Because of our mutual interest in this subject, we worked together and introduced electron diffraction in addition to the mass-spectrometry used to study the atomic ordering on single-crystal surfaces. From the results on surface atom reconstructions ("surface structures" of the crystal), we learned the conditions for growing high-quality, single crystalline films. A "surface phase diagram" was constructed from different stabilized surface structures.

Several obstacles were encountered in the development of MBE. From the surface physics studies in 1969, we could only grow a few hundred angstroms of GaAs in a day. These films were too thin for performing any electrical or optical evaluations at that time. It was not until 1970, when we introduced an additional Ga effusion oven and As_4 cracker effusion ovens[1] along with various dopant effusion ovens,[2] that MBE became a convincing new technology. From then on, the work was to prove that MBE could prepare all "standard" microwave and optical devices with as good as or better performance than existing technologies. Only after such a demonstration could MBE move on to produce a whole new generation of novel microwave, digital, and photonic devices.[3] Because MBE was extended into a variety of fields from surface and quantum physics, interface chemistry, and metallurgy to electrical engineering, it not only has contributed to many fundamental understandings of vacuum-solid and solid-solid interfaces but has also generated many novelties.[4]

1. **Cho A Y & Hayashi I.** Surface structures and photoluminescence of molecular beam epitaxial films of GaAs. *Solid State Electron.* **14**:125-32, 1971. (Cited 55 times.)
2. **Cho A Y.** Film deposition by molecular-beam techniques. *J. Vac. Sci. Technol.* **8**:S31-S38, 1971. (Cited 75 times.)
3. **Parker E H C**, ed. *The technology and physics of molecular beam epitaxy.* New York: Plenum Press, 1985. 679 p.
4. **Capasso F, Mohammed K & Cho A Y.** Tunable barrier heights and band discontinuities via doping interface dipoles: an interface engineering technique and its device applications. *J. Vac. Sci. Technol. B* **3**:1245-51, 1985.

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