

**Sturge M D.** Optical absorption of gallium arsenide between 0.6 and 2.75 eV.  
*Phys. Rev.* **127**:768-73, 1962.  
[Royal Radar Establishment, Malvern, England]

This paper reports the first observation of an exciton in a III-V semiconductor, and gives the first accurate values of the band gap of GaAs, of its temperature dependence, and of the exciton binding energy. [The *SCI*<sup>®</sup> indicates that this paper has been cited in over 505 publications since 1962.]

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"Early in 1961, when my research fellowship at the Royal Radar Establishment (RRE) was coming to an end, news came from Cyril Hilsum, at the Services Electronics Research Laboratory in Baldock, of the serendipitous discovery of 'semi-insulating' gallium arsenide.<sup>1</sup> A 'semi-insulator' is a semiconductor with a high density of impurity levels near the center of the forbidden band, so that it contains few free carriers even though its impurity content may be high by semiconductor standards. My colleague and mentor in infrared techniques, Alastair Johnson, acquired some of this material, and we agreed that I should look for exciton absorption at the band gap, while he concentrated on the phonon spectrum.

"My chief technical problem was to make the very thin ( $\sim 5 \mu\text{m}$ ) samples needed to get a reasonable transmission, epitaxial growth of GaAs being then unknown. Fortunately, John Quarrington and his assistants had developed the lapping of thin germanium wafers to a fine art, which with some care could be extended to make even thinner samples of the more friable GaAs. Without

air conditioning and with windows tightly shut to exclude dust, two patient assistants (Mrs. W. Lavin and Miss Jean Lloyd) polished many samples for me through a stifling summer. Then came the problem of transferring the sample to the cryostat; my wife came to dread the words, 'I've broken another sample.' Eventually, I enlisted the help of Norman Williams, who accomplished the transfer with a camel-hair brush reduced to a single hair. From then on it was straightforward spectroscopy.

"Mechanical polishing is a terrible thing to do to a crystal, and I had to correct for the strain it introduces in a somewhat *ad hoc* fashion. Ten years later Darrell Sell (then at Bell Labs) obtained much better data using etched, unstrained, epitaxially grown samples of much higher purity.<sup>2</sup> His results, on the whole, confirmed the correctness of my procedure. (For more recent work, see my introduction to *Excitons*.<sup>3</sup>)

"There are probably two reasons, both more or less accidental, for the high citation of this paper. For one thing, it was timely: the flood of publications which followed the invention of the GaAs light emitting diode and laser in 1962 had to cite it for the band gap. By this time I was at Bell Labs and working in a different field; Peter Price of IBM remarked that I had 'gotten out of GaAs just when it was getting interesting.' Oddly enough I'm back now, after 20 years.

"The other reason is that the paper caught the eye of Charles Kittel, who reproduced one of my spectra in the third and subsequent editions of his classic *Introduction to Solid State Physics*,<sup>4</sup> on which practically all students in the field cut their teeth. Vernon Roberts and his RRE colleagues had obtained similar data on the direct exciton in Ge four years earlier. However, they published in a British journal,<sup>5</sup> and the lesson is clear: if you want to be cited, use *Physical Review*."

1. Gooch C M, Hilsum C & Holeman B R. Properties of semi-insulating GaAs. *J. Appl. Phys.* **32**:2069-73, 1961.
2. Sell D D. Resolved free-exciton transitions in the optical absorption spectrum of GaAs. *Phys. Rev. B* **6**:3750-3, 1972.
3. Sturge M D. Introduction. (Rashba E I & Sturge M D, eds.) *Excitons*. Amsterdam: North-Holland, 1982.
4. Kittel C. *Introduction to solid state physics*. New York: Wiley, 1966. 648 p.
5. MacLarlaine G G, McLean T P, Quarrington J E & Roberts V. Direct optical transitions and further exciton effects in germanium. *Proc. Phys. Soc. (London)* **71**:863-6, 1958.  
[The *SCI* indicates that this paper has been cited in over 60 publications since 1961.]