

# Blue-violet electroluminescence and photocurrent spectra from polycrystalline chemical vapor deposited diamond film

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We have measured current–voltage characteristic, blue-violet electroluminescence (EL) and subgap photocurrent spectra of free standing polycrystalline chemical vapor deposited diamond film. The current increases as a power law function of the voltage with an exponent of about 5.5. The EL spectra show a main luminescence band peaked at 3.0 eV, whose intensity increases linearly with the electric current. The photocurrent increases rapidly with the photon energy in the range from 2.0 to 3.5 eV and then tends to saturate. It is found that all these results can be consistently explained in relation to gap states centered at 3.0 eV above the valence band. © 1995 American Institute of Physics.

Recently tremendous efforts have been made to develop visible–ultraviolet light emitting devices due to their great application potential for both scientific research and optoelectronic devices. Diamond could be a promising material because of its wide band gap of about 5.5 eV. In the last several decades, progress in technologies of synthesizing diamond, such as chemical vapor deposition (CVD) technique, has shown the possibility to get reasonably priced and high quality material. Perfect natural diamond has an indirect band gap, which prevents it from being efficient light emitting material, but in both natural and synthetic diamond intense luminescence may occur within the photon energy range from ultraviolet to near infrared.<sup>1</sup> The reason can be attributed to structural imperfections (e.g., dislocations, vacancies) and impurities which introduce gap states. In fact luminescence measurements have already been used extensively to characterize diamond by means of photon (UV to visible) and high energy particles (e.g., electron beam, alpha particles) as sources of excitation.<sup>2</sup>

The luminescence spectra of diamond may differ from sample to sample and depend also on measurement conditions such as temperature. However, a so-called “A” band, which is referred to a broad luminescence band whose peak may vary from about 3.0 to 2.0 eV with full width at half-maximum (FWHM) ranging from 0.35 to 0.5 eV, appears in almost all kinds of diamond.<sup>1,2</sup> To our knowledge, only few papers have been addressed to blue electroluminescence from natural<sup>3</sup> and CVD diamond film<sup>4–6</sup> in comparison with photo- and cathodoluminescence (PL, CL). On the other hand, it is still unclear about the origin of the “A” band so far.<sup>7</sup> Obviously, from the viewpoint of both device application and understanding of basic physics, more attention should be paid to electroluminescence (EL). The aim of the letter is to report blue-violet EL from a CVD diamond film

and to analyze it by means of current–voltage characteristic and subgap photocurrent spectrum.

The diamond sample was supplied by Norton Co., Northboro, Massachusetts, USA, prepared by the dc arc-jet technique and not intentionally doped. The film is about 400  $\mu\text{m}$  thick with an area of  $1 \times 1 \text{ cm}^2$ . The substrate and a part of the film (on the bottom) which contains graphite, amorphous carbon, and very small crystallites have been cut off. Electric contacts with an area of about  $8 \times 8 \text{ mm}^2$  on the polished surfaces have been deposited by subsequent evaporation of Ti/Pt/Au.<sup>8</sup>

All the measurements have been carried out at room temperature. The dark dc resistivity at low voltages ( $<100 \text{ V}$ ) is higher than  $5 \times 10^{15} \Omega \text{ cm}$ , beyond the limit of our electrometer (Keithley 617). However, as shown in Fig. 1, the dark current ( $J$ ) increases drastically from about 2 pA to 170  $\mu\text{A}$  as the applied dc voltage ( $V$ ) increases from 100 to 1320 V. The  $J$ – $V$  characteristic can be well fitted by a single power law function with an exponent of  $5.47 \pm 0.06$ . In the case of double carrier injection, when carrier recombination

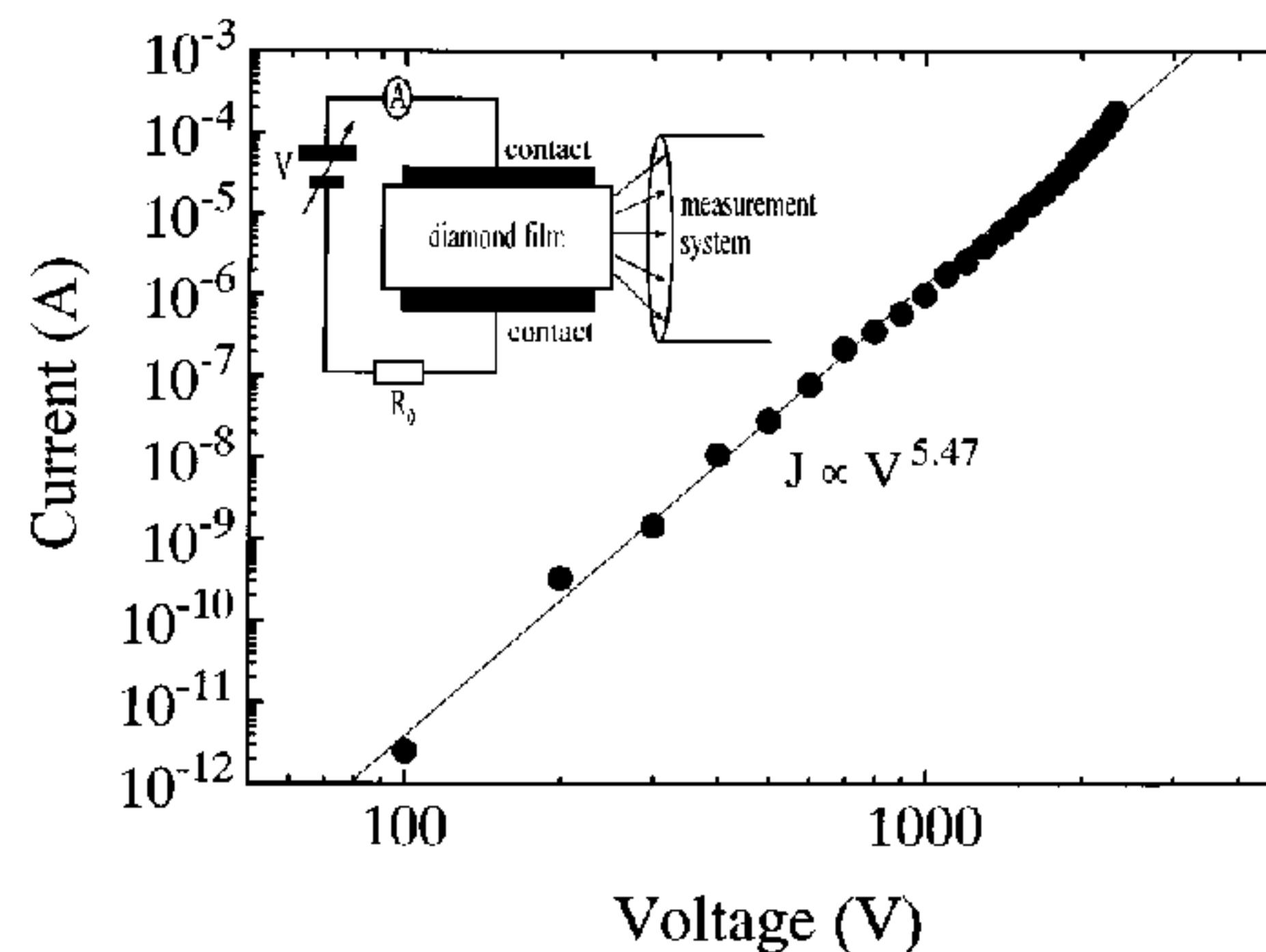


FIG. 1. The current–voltage characteristic of the sample. The inset schematically shows the experimental setup.

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