3-2 A New Spectroscopic Method of Measuring Transient Temperature Distribution in High Power Thyristors

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Synopsis

When a large area thyristor is turned on by a gate, the rapid local heating occurs in the initial conducting area due to the concentration of power dissipation.[1] This is a major limitation to the current ratings of power devices. To improve these, it is required to investigate a local distribution of the transient temperature. For this purpose, a microscopic infrared radiometer has been employed.[2] However, this method has several unavoidable inadequencies to the hot spot measurements, such as difficulties of emissivity correction, and an insufficient response speed of infrared detector systems.

A new spectroscopic method, which is free from the above difficulties, has been developed. By this method, the first direct measurement was made of an initial sharp peak of the temperature rise in power devices. When a thyristor is turned on, electroluminescent light is emitted from near the PN junction. Since the peak wave-length is about 1.1 μm, it is independent of sample thickness and surface treatment. It is also insensitive to impurity concentration.[3] Thus once a calibration curve of the peak wave-length vs the temperature is given in some way, the temperature can be determined by measuring the peak wave-length. The temperature dependence of photoluminescence spectra as illustrated in Fig. 1 is adopted as the calibration curve, reasonably assuming that temperature dependence of EL is identical with that of PL.[3] The time-resolved spectra were measured by using a monochrometor, photomultiplier, and sampling converter as shown in Fig. 2.

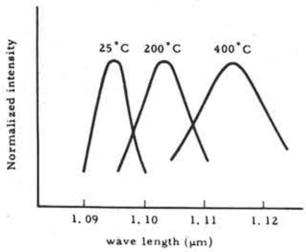

Fig. 1 The shift of the recombination radiation spectrum of Si due to a variation in temperature.

The devices used for temperature measurements were subjected to a 60 Hz, 37 μs, half-wave sinusoidal current pulses of 360 and 480 amperes peak respectively. The destructive di/dt limit was 90 amperes/μs. Since a hot spot usually occurs along the FI-gate for FI-type devices, three different spots along the FI-gate, labeled a, b, and c as in Fig. 3, were chosen for measurements. Fig. 3 shows the total intensity waveforms for each spot as indicated. A distinct feature in

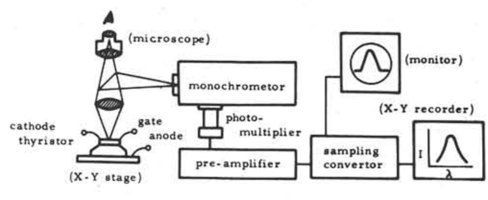

Fig. 2 Schematic diagram of the system used to obtain the time-resolved spectra of electroluminescence from the device.

these traces is that the initial intensity rises increase in order of a, b, and c. This may suggest that the conducting area was initiated at a and then spread towards c along the FI-gate, though the instantaneous intensity of electroluminescence is not necessarily proportional to the current density of the corresponding time. Fig. 4 shows the local temperature waveforms measured for a, b, and c with the anode current of 360 amperes peak and in addition b with 480 amperes peak respectively. Features apparent in this figure are as follows : Two peaks are clearly resolved. The first peaks appear almost at the same time for different spots. On the other hand, the second ones occur in coincidence in time with the corresponding peaks of the light intensity in Fig. 3. The results are explained by the hypothesis that the first peak of the temperature waveforms may be caused by the concentration of the power dissipation in an initial conducting area, and the rather broader second peak may correspond the current maximum in the whole conducting period. The transient temperature also varies with other parameters such as the anode current and the di/dt level. These effects will be also discussed.

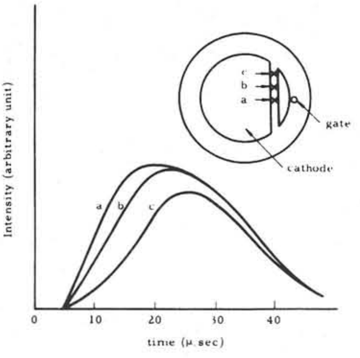

Fig. 3 A local variation of the total intensity waveforms of electroluminescence. The measured spots are indicated in a sketch of the device. The time origin is a triggered time.

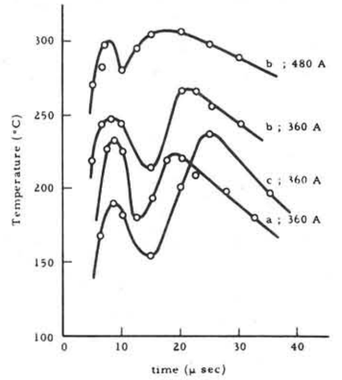

Fig. 4 Temperature waveforms for the spots a, b, and c with the anode current of 360 amperes peak and b with that of 480 amperes peak.

Fast response of temperature measurements has been achieved by a new spectroscopic method described above. By this method the initial sharp peak of the local transient temperature in power devices can be measured. The new method might be powerful to evaluate various designs of high power thyristors.

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