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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Methods for Minority-Carrier Lifetime in Bulk Germanium and Silicon by Measurement of Photoconductivity Decay¹

This standard is issued under the fixed designation F 28; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover the measurement of minority carrier lifetime appropriate to carrier recombination processes in bulk specimens of extrinsic single-crystal germanium or silicon.

1.2 These test methods are based on the measurement of the decay of the specimen conductivity after generation of carriers with a light pulse. The following two test methods are described:

1.2.1 *Test Method A*—Pulsed Light Method, that is suitable for both silicon and germanium.²

1.2.2 *Test Method B*—Chopped Light Method, that is specific to silicon specimens with resistivity $\geq 1 \Omega \cdot \text{cm}$.³

1.3 Both test methods are nondestructive in the sense that the specimens can be used repeatedly to carry out the measurement, but these methods require special bar-shaped test specimens of size (see Table 1) and surface condition (lapped) that would be generally unsuitable for other applications.

1.4 The shortest measurable lifetime values are determined by the turn-off characteristics of the light source while the longest values are determined primarily by the size of the test specimen (see Table 2).

NOTE 1—Minority carrier lifetime may also be deduced from the diffusion length as measured by the surface photovoltage (SPV) method made in accordance with Test Methods F 391. The minority carrier lifetime is the square of the diffusion length divided by the minority carrier diffusion constant which can be calculated from the drift mobility. SPV measurements are sensitive primarily to the minority carriers; the contribution from majority carriers is minimized by the use of a surface depletion region. As a result lifetimes measured by the SPV method are often shorter than lifetimes measured by the photoconductivity decay (PCD) method because the photoconductivity can contain contributions from majority as well as minority carriers. In the absence of carrier trapping, both the SPV and PCD methods should yield the same values of

¹ These test methods are under the jurisdiction of ASTM Committee F-1 on Electronics and are the direct responsibility of Subcommittee F01.06 on Silicon Materials and Process Control.

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² This test method is based in part on IEEE Standard 225, Proceedings IRE, Vol 49, 1961, pp. 1292–1299.

³ DIN 50440/1 is an equivalent test method. It is the responsibility of DIN Committee NMP 221, with which Committee F-1 maintains close liaison. DIN 50440/1, is available from Beuth Verlag GmbH, Burggrafenstrasse 4-10, D-1000 Berlin 30, FRG.

TABLE 1 Dimensions of Three Recommended Bar-Shaped Specimens

Type	Length, mm	Width, mm	Thickness, mm
A	15.0	2.5	2.5
B	25.0	5.0	5.0
C	25.0	10.0	10.0

TABLE 2 Maximum Measurable Values of Bulk Minority Carrier Lifetime, τ_B , μs

Material	Type A	Type B	Type C
p-type germanium	32	125	460
n-type germanium	64	250	950
p-type silicon	90	350	1300
n-type silicon	240	1000	3800

lifetime (**1**)⁴ providing that the correct values of absorption coefficient are used for the SPV measurements and that the contributions from surface recombination are properly accounted for in the PCD measurement.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Specific hazard statements are given in Section 9.*

2. Referenced Documents

2.1 ASTM Standards:

D 1125 Test Method for Electrical Conductivity and Resistivity of Water ⁵

F 42 Test Method for Conductivity Type of Extrinsic Semiconducting Materials ⁶

F 43 Test Method for Resistivity of Semiconductor Materials ⁶

F 391 Test Methods for Minority Carrier Diffusion Length in Extrinsic Semiconductors by Measurement of Steady-State Surface Photovoltage ⁶

2.2 Other Standards:

DIN 50440/1 Measurement of Carrier Lifetime in Silicon Single Crystals by Means of Photoconductive Decay: Measurement on Bar-Shaped Test Specimens ³

⁴ The boldface numbers in parenthesis refer to a list of references at the end of these test methods.

⁵ Annual Book of ASTM Standards, Vol 11.01.

⁶ Annual Book of ASTM Standards, Vol 10.05.