

Microwave Losses / 2-Level Systems (TLS) in Dielectrics

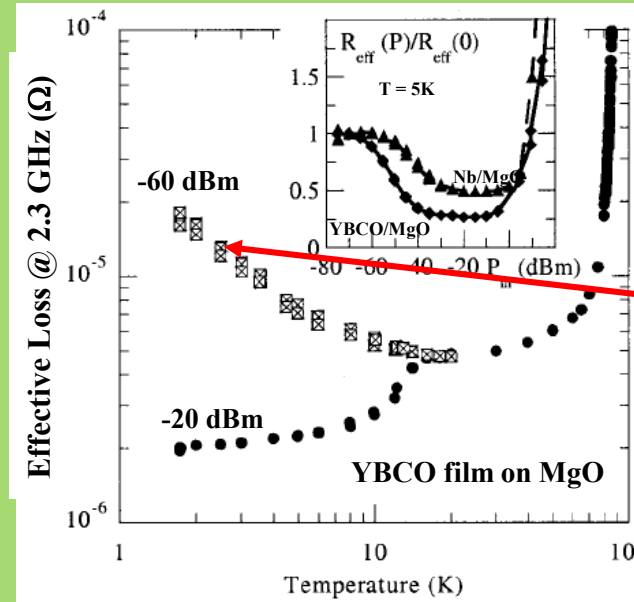
Classic reference:

Two-level states in glasses

W A Phillips

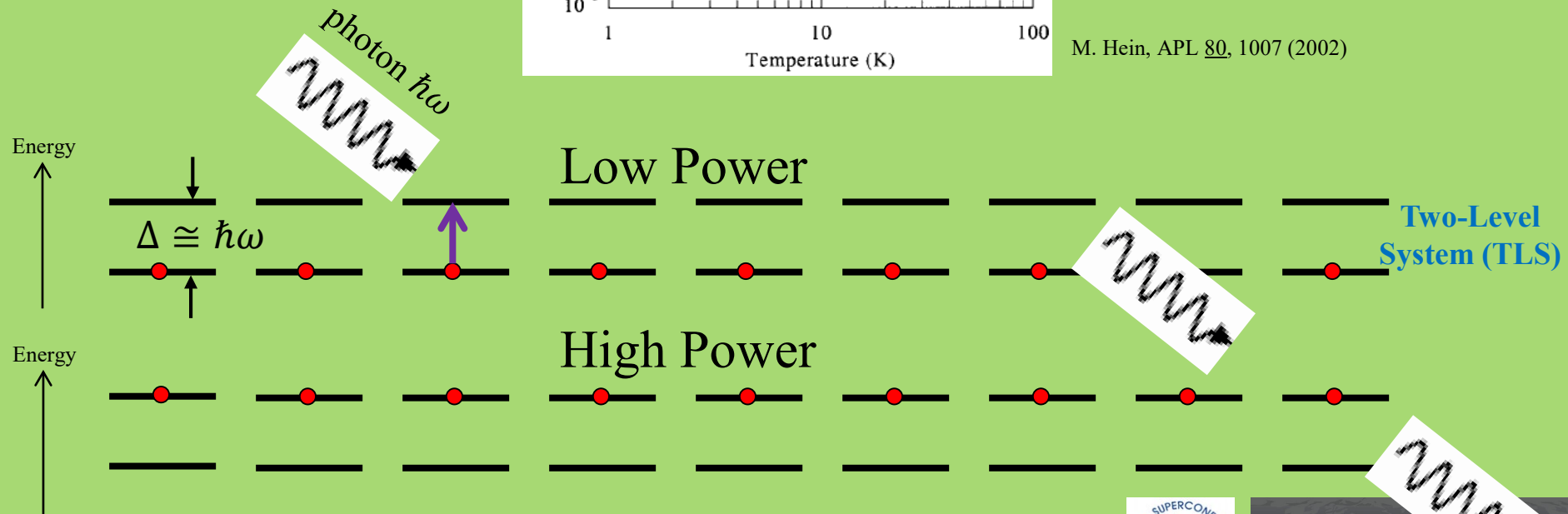
Rep. Prog. Phys. **50** (1987) 1657-1708.

TLS in MgO substrates



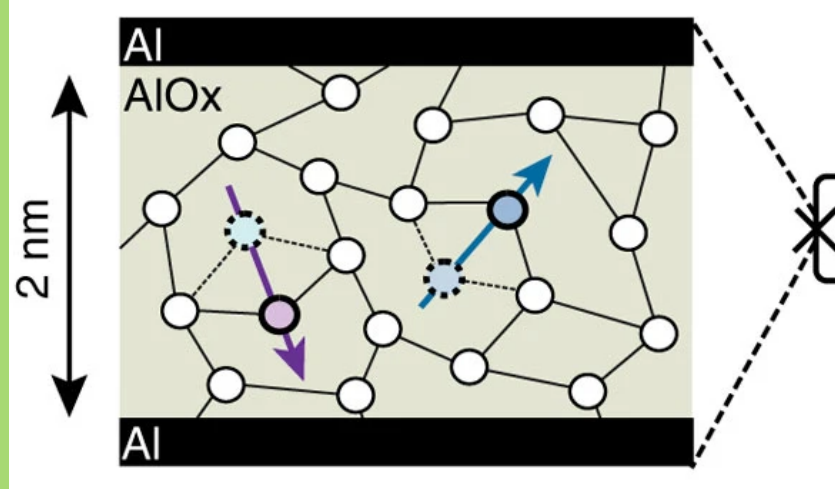
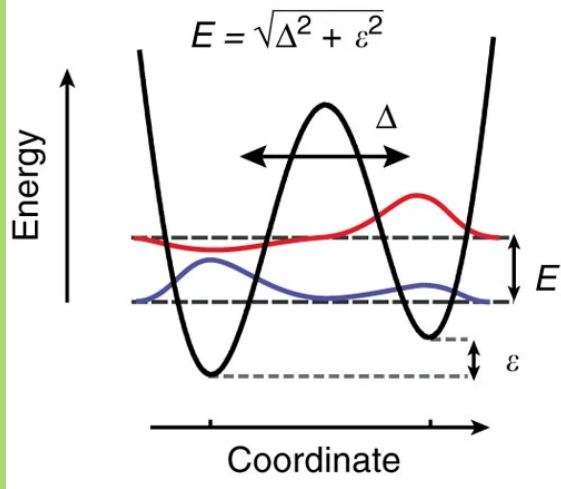
The increase in loss as temperature decreases for -60 dBm is due to the TLS relaxing back to their ground state

M. Hein, APL **80**, 1007 (2002)

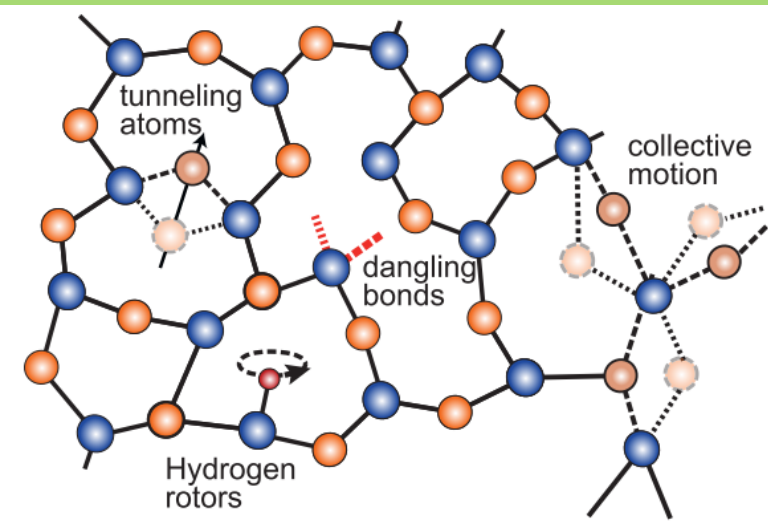
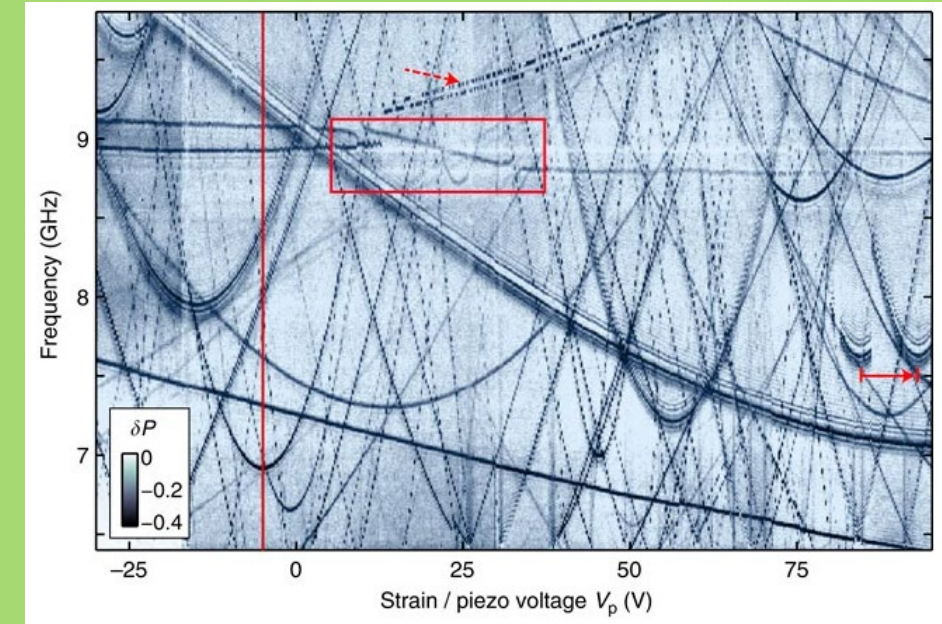


What are the two-level systems microscopically?

Two-Level System Energies



J. Lisenfeld, *et al.*, *Nat Commun* **6**, 6182 (2015)



C. Müller *et al.*, *Rep. Prog. Phys.* **82** 124501 (2019)

Figure 3. Illustration of some example mechanisms of TLS formation in an amorphous material: tunneling of single atoms and collective motion of small atomic groups, dangling bonds, and hydrogen defects.

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