Abstract

A semiconductor device has a semiconductor assembly and an antenna substrate formed separate from the semiconductor assembly and mounted to the semiconductor assembly. A bonding material is disposed between the antenna substrate and semiconductor assembly. An encapsulant is deposited over the antenna substate. The encapsulant may be planar or have encapsulant bumps. The bonding material extends over a side surface of the antenna substrate. The antenna substrate has a first antenna substrate and a second antenna substrate disposed over the semiconductor assembly. The first antenna substrate is offset with respect to the second antenna substrate in the horizontal and/or vertical directions. The antenna substrate can fan out from the semiconductor assembly. The semiconductor assembly can have multiple layers of core material with different coefficient of thermal expansions. A heat sink or shielding layer can be formed over the antenna substrate and semiconductor assembly.

(Fig. 6a)