DESIGN AND ANALYSIS OF MAGNETIC-CORE INTER-WAFER INDUCTOR SUPPORTING THREE DIMENSIONAL POWER DELIVERY

By

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ABSTRACT

Power delivery has become a major issue in deep sub-micron microprocessors due to the rapid increase in power density and frequency. Upcoming microprocessors will require hundreds of amps; thus a solution for power delivery is required.

Increasing input voltage, moving the power regulator closer to the microprocessor by integrating it on chip, or using on-chip inductors operating at higher frequency can alleviate the conventional power delivery problems. However, it is difficult to integrate an on-chip inductor with a soft magnetic core due to iron and other soft magnetic materials' CMOS processing incompatibility. Air core inductors are not sufficient for use in DC-DC converters as these result in increased area, low yield, and poor performance from substrate losses.

Three dimensional (3D) hyper-integration provides a potential solution for power delivery systems by integrating inter-wafer inductors with a magnetic core into monolithic power delivery circuitry. In such a 3D power delivery architecture an inductor with a soft ferrite core, wound much like a discrete component, can be used.

This work discusses the the implications of 3D hyper-integration to DC-DC conversion for high power microprocessors. Using an inductor with a soft ferrite core, the loss due to the inductor can be reduced by a third, and a 80% efficiency can be achieved. A process for constructing an inductor with a soft magnetic core that can handle 100 mA and function at frequencies above 100 MHz is described. Tests of key process steps at the 10-100 micron scale required for a DC-DC converter inductor and rules and methods for the inductor design masks are shown.