



US006970362B1

(12) **United States Patent**
Chakravorty

(10) **Patent No.:** **US 6,970,362 B1**
(45) **Date of Patent:** **Nov. 29, 2005**

(54) **ELECTRONIC ASSEMBLIES AND SYSTEMS**
COMPRISING INTERPOSER WITH
EMBEDDED CAPACITORS

(75) Inventor: **Kishore K. Chakravorty**, San Jose,
CA (US)

(73) Assignee: **Intel Corporation**, Santa Clara, CA
(US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 459 days.

(21) Appl. No.: **09/628,705**

(22) Filed: **Jul. 31, 2000**

(51) Int. Cl.⁷ **H05K 7/02**; H05K 7/06;
H05K 7/08; H05K 7/10

(52) U.S. Cl. **361/782**; 361/764; 361/765;
361/306.3

(58) Field of Search 361/760-764,
361/306.1, 306.2, 306.3; 174/259-261; 257/700-704,
257/723-724; 29/25.42

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,567,542 A	1/1986	Shimada et al.	361/321
4,926,241 A	5/1990	Carey	357/75
5,027,253 A	6/1991	Lauffer et al.	361/321
5,060,116 A	10/1991	Grobman et al.	361/474
5,177,594 A	1/1993	Chance et al.	257/678
5,177,670 A	1/1993	Shinohara et al.	361/388
5,271,150 A	12/1993	Inasaka	
5,281,151 A	1/1994	Arima et al.	439/68
5,321,583 A	6/1994	McMahon	361/770
5,354,955 A	10/1994	Gregor et al.	174/250
5,377,139 A	12/1994	Lage et al.	365/154
5,469,324 A	11/1995	Henderson et al.	361/301.2
5,488,542 A	1/1996	Ito	361/793
5,639,989 A	6/1997	Higgins, III	174/35 MS
5,691,568 A	11/1997	Chou et al.	257/691
5,714,801 A	2/1998	Yano et al.	257/691
5,736,448 A	4/1998	Saia et al.	438/393

5,745,335 A	4/1998	Watt	361/313
5,777,345 A	7/1998	Loder et al.	257/777
5,786,630 A	7/1998	Bhansali et al.	257/697
5,796,587 A	8/1998	Lauffer et al.	361/763
5,818,699 A	10/1998	Fukuoka	361/760
5,840,382 A	11/1998	Nishide et al.	428/209
5,870,274 A	2/1999	Lucas	361/311
5,870,289 A	2/1999	Tokuda et al.	361/779
5,889,652 A	3/1999	Turturro	361/705
5,920,120 A	7/1999	Webb et al.	257/719

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0359513 3/1990

(Continued)

OTHER PUBLICATIONS

Amey, D., et al., "Advances in MCM Ceramics", *Solid State Technology*, 143-146, (1997).

(Continued)

Primary Examiner—Kamand Cuneo

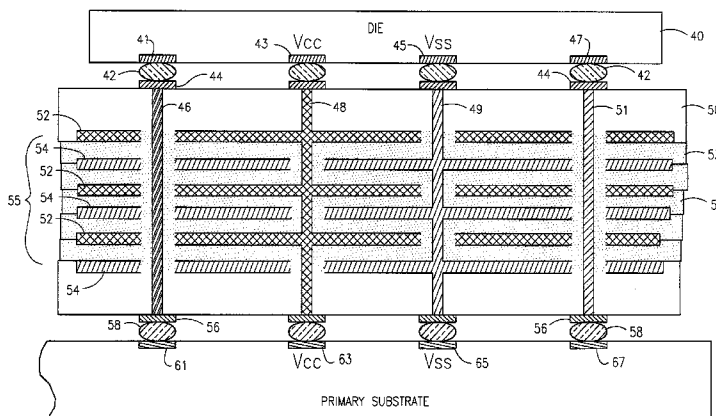
Assistant Examiner—Tuan Dinh

(74) *Attorney, Agent, or Firm*—Schwegman, Lundberg,
Woessner & Kluth, P.A.

(57) **ABSTRACT**

To reduce switching noise, the power supply terminals of an integrated circuit die are coupled to the respective terminals of at least one capacitor embedded in an interposer that lies between the die and a substrate. In an embodiment, the interposer is a multilayer ceramic structure that couples power and signal conductors on the die to corresponding conductors on the substrate. The capacitor is formed of at least one high permittivity layer and in an embodiment comprises several high permittivity layers interleaved with conductive layers. Alternatively, the capacitor can comprise at least one embedded discrete capacitor. Also described are an electronic system, a data processing system, and various methods of manufacture.

24 Claims, 8 Drawing Sheets



U.S. PATENT DOCUMENTS

5,929,510	A	7/1999	Geller et al.	257/635
5,939,782	A	8/1999	Malladi	257/698
5,949,654	A	9/1999	Fukuoka	361/760
5,991,161	A	11/1999	Samaras et al.	361/760
6,061,228	A	5/2000	Palmer et al.	361/306.2
6,072,690	A	6/2000	Farooq et al.	361/321.2
6,075,427	A	6/2000	Tai et al.	333/219
6,088,915	A	7/2000	Turturro	29/840
6,097,609	A	8/2000	Kabadi	361/760
6,097,611	A	8/2000	Samaras et al.	361/760
6,104,599	A	8/2000	Ahiko et al.	361/306.3
6,183,669	B1	2/2001	Kubota et al.	252/518.1
6,218,729	B1	4/2001	Zavrel, Jr. et al.	257/698
6,252,761	B1	6/2001	Branchevsky	361/321.2
6,407,929	B1*	6/2002	Hale et al.	361/763
6,446,317	B1*	9/2002	Figueroa et al.	29/25.42
6,452,776	B1	9/2002	Chakravorty	361/303
6,532,143	B2*	3/2003	Figueroa et al.	361/301.4
2004/0238942	A1	12/2004	Chakravorty et al.	

FOREIGN PATENT DOCUMENTS

EP	0656658	6/1995
JP	07-142867	6/1995
JP	08-172274	7/1996
JP	10-163447	6/1998
WO	WO-97/50123	12/1997
WO	WO-98/39784	9/1998
WO	WO-00/21133	4/2000
WO	WO-01/00573	1/2001

OTHER PUBLICATIONS

Baniecki, J., et al., "Dielectric Relaxation of Ba_{0.7} Sr_{0.3} TiO₃ Thin Films from 1 mHz to 20 GHz", *Appl. Phys. Letter* 72 (4), 1998 American Institute of Physics, 198-500, (Jan. 1998).

Chan, Y., et al., "Fabrication and Characterization of Multilayer Capacitors Buried in a Low Temperature Co-Fired Ceramic Substrate", *Active and Passive Elec. Comp.* vol. 20, 215-224, (1998).

Choi, K.L., et al., "Characterization of Embedded Passives Using Macromodels in LTCC Technology", *IEEE Transactions on Components, Packaging, and Manufacturing Technology*, vol. 21, 258-268, (Aug. 1998).

Eurskens, W., et al., "Design and Performance of UHF Band

Inductors, Capacitors and Resonators Using LTCC Technology for Mobile Communication Systems", *1998 IEEE MTT-S Digest*, 1285-1288, (1998).

Koschmieder, T., et al., "Ceramic Substrate Thickness, Test Board Thickness, and Part Spacing: A Screening Doe", *Proceedings of SMTA International Conference*, 6 pgs., (Sep. 1999).

Mistler, R.E., "Tape Casting: Past, Present, Potential", *The American Ceramic Society Bulletin*, 82-86, (Oct. 1998).

Nishimura, T., et al., "3.5 V Operation Driver-Amplifier MMIC Utilizing SrTiO₃ Capacitors for 1.95 GHz Wide-Band CDMA Cellular Phones", *1998 IEEE MTT-S Digest*, 447-450, (1998).

Rector, Jr., J., et al., "Integrated and Integral Passive Components: A Technology Roadmap", *1997 Electronic Components and Technology Conference*, 713-723, (1997).

Scrantom, S., et al., "Manufacture of Embedded Integrated Passive Components into Low Temperature Co-Fired Ceramic Systems", *1998 International Symposium on Microelectronics*, 459-466, (1998).

Sugai, K., et al., "Multilayer Alumina Substrates for ECU", *1998 IEEE/CPMT Berlin Int'l Electronics Manufacturing Technology Symposium*, 109-112, (1998).

Tok, A.I., et al., "Tape Casting of Composite Ceramic Substrates Using Hollow Micro-Spherical Powders", *Processing and Fabrication of Advanced Materials VII*, Proceedings of a Symposium organized by: The Minerals, Metals & Materials Society (TMS), Warrendale, PA, USA, 451-461, (Oct. 1998).

Ueda, T., et al., "GaAs MMIC Chip-sets for Mobile Communication Systems with On-Chip Ferroelectric Capacitors", *Integrated Ferroelectrics*, vol. 7, 45-60, (1995).

Williamson, III, W., et al., "High Frequency Dielectric Properties of PLZT Thin Films", *Integrated Ferroelectrics*, vol. 17, 197-203, (1997).

Yamasaki, K., et al., "Solder Column Interposer Grid Array—Improved CBGA Reliability", 1-9.

Yao, K., et al., "Improved Preparation Procedure and Properties for a Multilayer Piezoelectric Thick-Film Actuator", *Sensors and Actuators A 71*, 139-143, (1998).

* cited by examiner

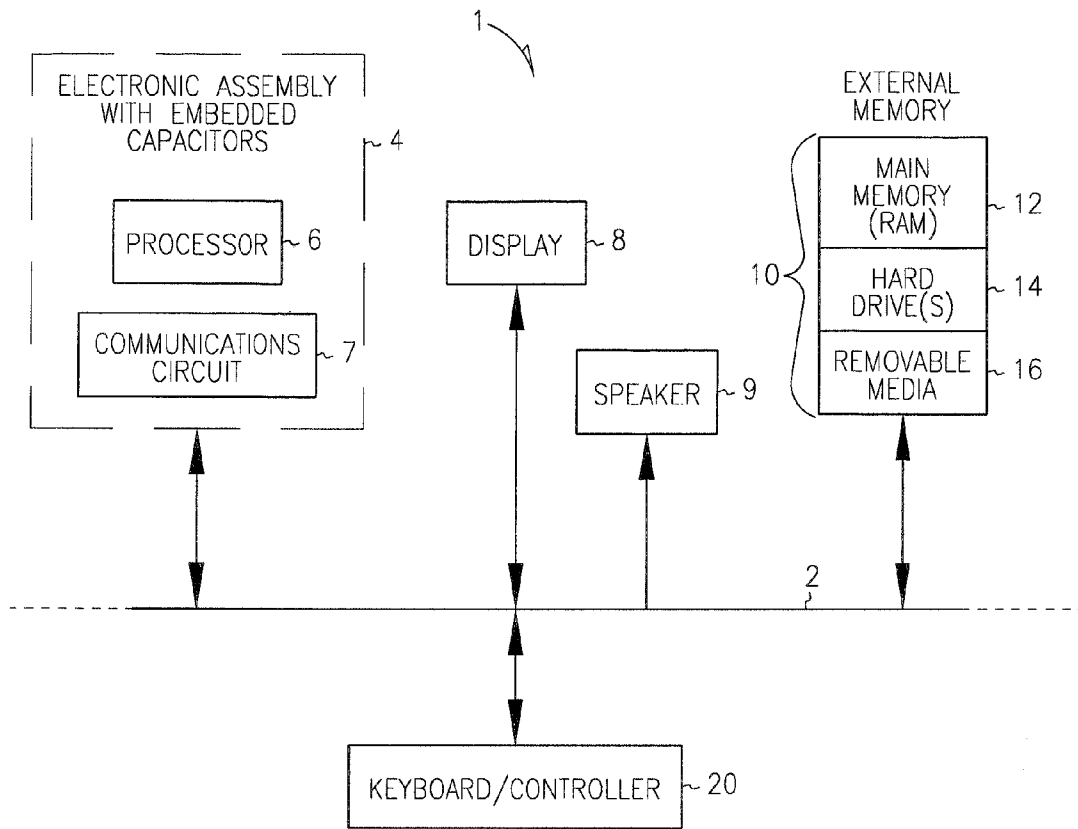


Fig. 1

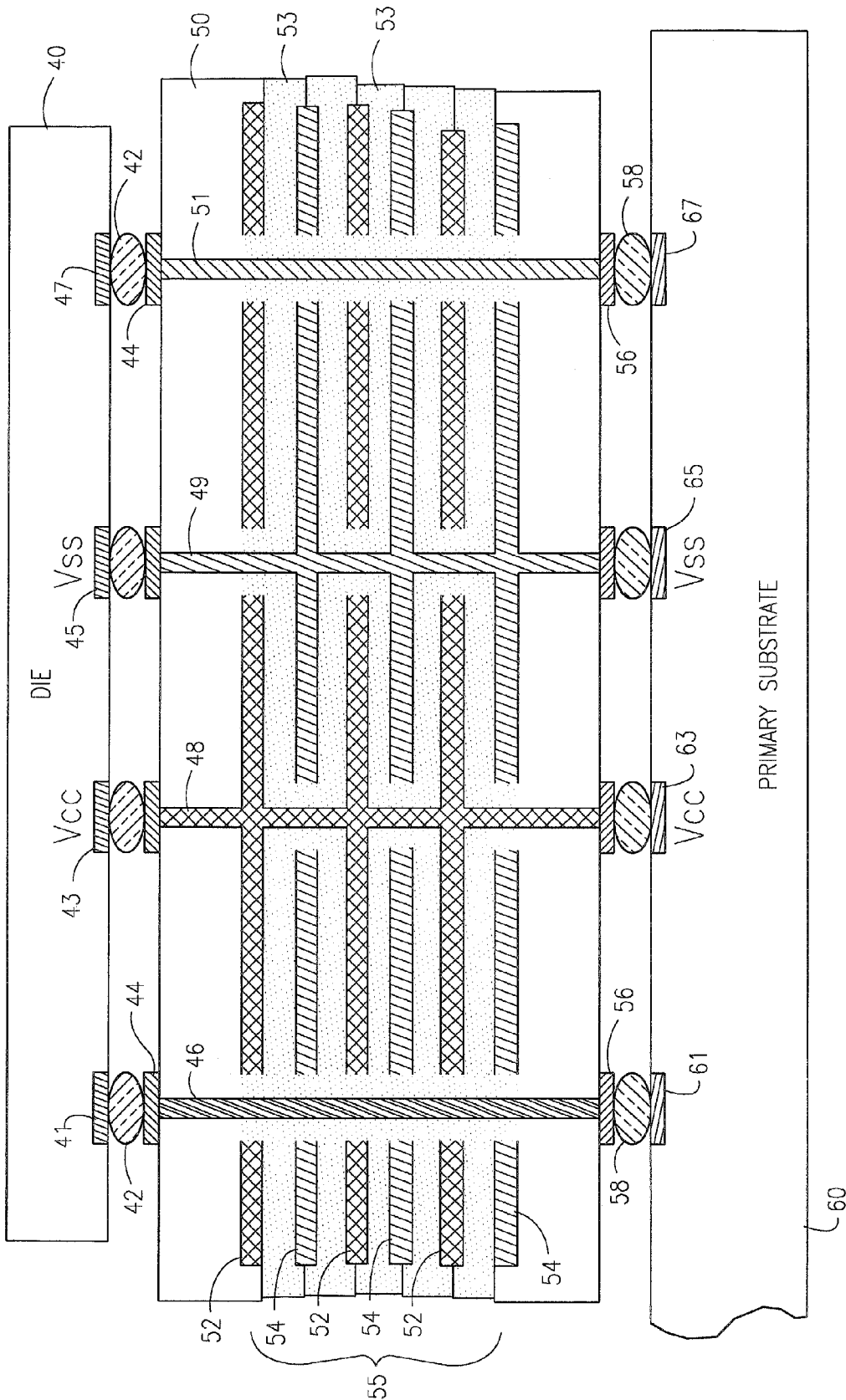


Fig. 2

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.