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Dear Arnold

INMOS - TECHNOLOGICAL EDGE AND COMPETITIVENESS

Following the presentation by INMOS yesterday morning and the subsequent discussion with your Minister of State, I met with Barron, Petritz and Heightley to discuss the competition in INMOS' market sectors. Vivian Brown was also at the meeting.

2. The main question I addressed was along the following lines:

INMOS has achieved very high penetration in the market for high speed static RAMs, due primarily to being the first into the market. However other companies, primarily Japanese, are closing the gap and so the competition in the premium market will be much more severe in 1983 and 1984. On what does INMOS base its confidence that it will retain a sizeable market share and that it will not be priced out by the Japanese high-volume manufacturers?

3. I also raised specific questions on the impact of INMOS' business of:

- the likely shift towards semi-custom devices at the expense of standard devices (for example, as predicted in the SRI report to BTG);
- the increasing preference for CMOS technology as opposed to NMOS technology;
- the possible move to 5" or 6" silicon wafers;
- any move to sub-micron technology.

4. I have listed observations against the points in paragraph 3 in the attachment. They are mostly detailed technological points. The INMOS answers were consistent with views I have heard expressed by members of the semiconductor industry. For

the reasons given in the attachment, INMOS is well placed to cope with any such changes in technology. They are not in any case expected to affect products in 1983 and 1984.

5. I have also dealt with technical aspects of the major question in paragraph 2 in the attachment. However the main messages are that:

i. the INMOS share of the premium (high speed) market will fall due to other entrants but the market in RAMs will grow sufficiently fast to compensate;

ii. INMOS expects still to have unique (highest speed) products through 1983 and 1984, enabling them to maintain an average price per chip well above the industrial average;

iii. the INMOS devices themselves have not reached the limits of their performance. Faster speeds, better chip carriers, and better design features will be coming through (14 new product launches are envisaged in 1983, all variants on the two main RAM products and the non-volatile memory);

iv. there is a good deal of inertia in Defence purchasing, due to lengthy acceptance tests and the choice of chip-packaging, that should sustain the highly profitable defence sales (currently 25% of the revenue comes from 5% of the devices) though prices will fall;

v. with volume production in Newport, following achievement of at least 25% yields in Colorado, the company is sufficiently far down the learning curve that there is no reason to expect any other company to achieve lower manufacturing costs.

6. Having made those points, it remains true of course that INMOS is no more immune than any other company to predatory pricing by comeptitors, involving cross-subsidies from other business areas. The lack of financial head-room does then force a heavy emphasis on maintaining the technological lead as the main defence and here the INMOS track record is good. In general, the market should grow sufficiently fast to ensure that, for practical purposes, the INMOS revenue is bounded by thier production capabilities.

7. I have not dealt with the transputer which will have little impact on revenue during 1983 and 1984.

Yours sincerely

DR P T DAVIES

Copies to: John Sparrow, John Stuttard, Robin Nicholson, Jack Leeming and Vivian Brown

INMOS - TECHNOLOGICAL EDGE AND COMPETITIVENESS

Random Access Memories

1. The market for random access memories (RAMs) is broadly partitioned by:

- size of memory (eg 16k or 64k);

- static (best, as holds contents indefinitely whilst power is on but needs complex circuitry) versus dynamic (less complex chip but needs refreshing);

- configuration of memory (eg 16k x 1 or 4k x 4 which affects suitability for different markets);

- speed of access (market has always moved to the fastest products);

- type of packaging and carrier (often subject to acceptance tests by customer, particularly for defence applications, and therefore inducing an inertia, ie semi-captive long-term customers, into the market).

2. All the characteristics are mainly determined by the design of the device and the fabrication equipment, which is of course susceptable to copying. However the control of the manufacturing process is responsible for the last bit of improvement in the access time and is therefore controlled by a learning curve. Thus the 45 nanosecond and 55 nanosocord 16k RAMs produced by INMOS are all produced by the same process but some of them are faster than others. If the yield of the very best devices is reliable and sufficient then a product can be launched. In time, further improvements in speed will be possible. It would not be possible for another company, without a very different technology, to go straight to the fastest devices at a competitive price without itself going down the learning curve.

INMOS 16k STATIC RAM

3. The INMOS 1982 Long Range Plan (LRP) assumes a world market for the high speed devices at $104M in 1983 and rising at 40% pa. This is broadly consistent with, though on the conservative side of, forecasts by SRI and Dataquest.

4. The market can be subdivided by access times of (nominal) 45ns, 55ns and 70ns, by configuration of memory, and by the type of packaging and mountings applied to the chips. INMOS has introduced a wide range of the latter (the order of 15) and has gained Defence approvals for some of the more expensive types (eg hermetic casings versus plastic). It has introduced 16k x 1 and 4k x 4 configurations which will sell in roughly equal quantities. INMOS serves the complete market and until recently was the only company to offer 45ns and 55ns devices, hence 75% penetration in 1982. INMOS is not in the slow 16k device market to any appreciable extent. Average prices there are 2-3 times lower than in the high speed market.

5. Fujitsu has now entered with a 55ns device. Hitachi and NEC may follow in 1983 and INMOS has revised its 1983 and 1984 market penetration to 53% and 51% respectively. Thereafter it might fall to 35%. During 1983 it still expects to maintain its lead with the 45ns device, this may be the case for 1984 but a 35ns INMOS chip might then be available.

High-Speed 16k RAMs - INMOS Assumptions

	World Market	Market Served	Penetration of Served	Shipped Units	Billing	Average Price
1983	$104M	$104M	53%	6.6M	$55M	$8.3
1984	$148M	$148M	51%	12.5M	$75M	$6

64k Dynamic RAMs

6. This market is predicted to grow very fast as 64k memories will be the work-horse of the computer industry; perhaps by a factor of five or six over the period 1982 to 1987. SRI predictions are for a demand of 250M units in 1982 with 10% being for high-speed devices. These predictions may in fact be low because the major computer manfuacturers, such as IBM, which might be expected to produce, in house, their own chips are having problems with yield and costs and are likely to buy-in significant amounts. A number of prominent companies, such as INTEL, failed to make an early entry due to the technical challenge of the product but even so there will be four or five companies operating in 1983 in the high speed market defined by access times of 100ns - 150ns. As yet, only INMOS offers a 100ns product.

7. The other strengths of INMOS include the Defence-approved packaging and chip carriers, design features such as the "nibble mode" (circuitry to allow rapid recall from more than one memory address), and unique configurations. The 16k x 4 and 8k x 8 DRAMs will be launched in Q1 1983 and should be the first entries in those configuration to the high speed market. The next step will be to static 64k RAMs early in 1984.

8. INMOS assesses its share of the high speed market at 24% in 1983 and 30% in 1984.

64k Dynamic RAMs - INMOS Assumptions

		World Market	Market Served	Penetration of served	Shipped Units	Billings	Average Price
1983	64kx1	$935M	$84M	24%	2.5M	$17.6M	$7
	16kx4				0.3M	$ 2.1M	$7
	8kx8				0.1M	$ 0.8M	$8
1984	64kx1	$1600M	$250M	30%	10 M	$52.5M	$5
	16kx4				2.8M	$14M	$5
	8kx8				1.0M	$ 6M	$6

Non-Volatile Memories

9. Most semiconductor memories are erased once the power is switched off. They are therefore suitable for short-term memory typically associated with holding transient information in support of calculations within a computer, telecommunications or whatever. The market for cheap devices which can store data or instructions indefinately is enormous but particularly if the contents can be updated from time to time (a programable read-only memory, PROM). To specify a growth rate is meaningless because the current volume of the market is very small and limited by what is available. EPROMs are available but need to be completely erased before updating by shining ultra-violet light on them. This can be inconvenient and leads to costly packaging.

10. An electrically erasable PROM (an EEPROM) is the ideal solution and INMOS expects to launch its commercial device in the second half of 1983. It will be a fast 64k device in an 8k x 8 configuration. Other entrants in the market are

likely to follow in the subsequent year, driving the price and INMOS' market share down. However the typical advantages accruing to the market leader in RAMs should also obtain here.

64k EEPROM - INMOS Assumptions

	World Market	Market Served	Penetration of served	Shipped Units	Billings	Average Price
1983	$73M	$10M	60%	0.09M	$6.2M	$69
1984	$129M	$40M	42%	0.8M	$16.7M	$21

Other Technological Developments

Shift towards semi-custom devices as oppposed to standards

11. This point was made in the SRI report to BTG. However it is not, even by SRI's predictions which are more forthright on this topic than others, likely to have a big impact on INMOS over the next five years. The MOS standards market is predicted to grow three-fold between 1982 and 1987; in so doing it will decline from 78% of the world market to 69% to the benefit of semi-custom devices.

12. Should there be a greater emphasis on the switch to semi-custom then INMOS, with its first rate design team, its transputer concept which will allow some customising on-chip and its CAD system for fast design, will be as well placed as any company to compete.

Shift towards CMOS and away from NMOS technology.

13. Broadly, CMOS allows lower power consumption, hence less heat dissipation problems and closer packing. The CMOS manufacturing process is closely related to NMOS process though with a couple of stages added. Expensive new fabrication plant is not needed, typically two or three new furnaces are required. The main cost in switching from NMOS (which is INMOS' dominent technique at present) to CMOS is related to the redesign of chips and the generation of new know-how.

14. INMOS plans that its 64k static RAMs will be launched in CMOS and CMOS 16k SRAMs and 64k DRAMS will be brought in if the market demands it.

Move to 5" or 6" silicon wafers.

15. The INMOS "steppers" (moving the lithographic process across the face of the silicon wafers) are the most up to date that can be bought and could take 5" wafers, though other aspects of the handling process would have to change. Currently they use 4" wafers which is the leading-edge of the technique. There have traditionally been cost advantages in going to bigger wafers (the majority of manufacturers still use 3" wafers becuase of old fabrication machinery) but advantages are now being constrained by limits to surface regularity across the big wafers.

16. It would be costly for INMOS to convert to larger wafers but it is unlikely to be an issue in the next five years.

Move to sub-micron technology

17. Manufacturers at the leading-edge are currently dealing with lines, on the chip, of 2-3 microns. Sub-micron tehcnology is foreseeable but many years off for commercial, volume manufacturing.