Digital Micromirror Device (DMD™)

From R&D to a Profitable Business
Sherel D. Horsley
DMD the "Digital Light Switch"

- Mirror size 17 um
- Mirror switching time 20 us
- Mirror tilt angle 10 degrees
- Pulse modulation control
How an image is created

1. Light Source
2. Projection Lens
3. Light Absorber
4. 3 DMD Micromirrors

(Actual Top View)
1987  Digital Mirror Invention
Late ‘80’s Contracts with Rank and ARPA
1991  Focused business unit formed
1991-95  Massive investment R&D (> 500 patents)
1995  First Revenue
1996  Mass production
2000  Profitability achieved

Dr. Larry Hornbeck
Micromirror Inventor
Making the Device

• Silicon processing
• 0.8 micron design rules
• 150 mm wafer size

Standard SC Stuff, Right?
WRONG!

• Very large die sizes (.7”-1.1”)  
  - 42-112 devices per wafer  
  - defect density implications

• 3-D particle implications

• Optical implications  
  - optically coated windows  
  - aperture requirement

• Complex Assembly/Test process  
  - KGD only at final process step  
  - People intensive process

Bottom Line: Very Low Yields
The Starting Business Strategy

• Try to compete in all projection markets
• Introduce a mid-priced network printer
• Sell to any and all customers
• Build as much of the final projection product as possible ourselves
• Establish a unique brand identity for our DMD technology
Market Impedance

- Projection market dominated by LCD technology ($2B annual R&D investment in Japan)
  - polysilicon
  - polarization recapture
  - etc.

- Projection market less than 100,000 units annually and growth is uncertain

- Digital printing market dominated by strong Japanese companies and prices going down

- DMD technology not well understood by customers

- TI’s staying power questioned
What Did We Do

• Exit the digital printing business
What Did We Do

• Exit the digital printing business

• Redirect our emphasis to where we had defensible value
DLP Value Proposition

- Cinema
- Auditorium
- Video Wall
- Conference room (ultra-portable)
- Home Entertainment

*Up in brightness & resolution*

- 15000 L
- 10000 L
- 5000 L
- 2000 L

*Down in cost & weight*

- Sub 10 lb
- Sub 5 lb
- Sub 3 lb
- Sub 10 lb
- Sub 5 lb
- Sub 3 lb
What Did We Do

• Exit the digital printing business
• Redirect our emphasis where we had defensible value
• Change Product Offering to match our competencies
DLP Product Evolution

**Engine**
- Turnkey solution for OEM
- Inefficient end product design
- Significant non-value added content

1996

**Subsystem**
- OEM design flexibility
- TI core competence
- Smaller designs

1997

**Component Kit**
- Maximum OEM design flexibility
- Even smaller designs
- Maximum OEM product differentiation
- High value added

1999
What Did We Do

• Exit the digital printing business
• Redirect our emphasis where we had defensible value
• Change product offering to match our competencies
• Link with strong OEM’s
OEM Attributes

Phase 1—build the market confidence in DLP
• Strong market presence and share e.g. InFocus
• Strong affinity for the technology e.g Digital Projection Limited, Davis
• Design Creativity and innovation e.g. Plus Corporation

Phase 2—exploit the perceived market value
• Market channels and brand e.g. Sony, Panasonic, Sharp, NEC, Barco, Mitsubishi
What Did We Do

• Exit the digital printing business
• Redirect our emphasis where we had defensible value
• Link with strong OEMs
• Change product offering to match our competencies
• Move to new manufacturing processes
New Manufacturing Technology Implementation

• Move to 0.5 micron design rules
  .7” XGA vs .9”

• 200 mm wafer
  112 XGA devices/wafer vs. 56

• Higher level of automation in A/T

• Integration with the rest of our semiconductor manufacturing operations
What Did We Do

- Exit the digital printing business
- Redirect our emphasis where we had defensible value
- Link with strong OEMs
- Change product offering to match our competencies
- Move to new manufacturing processes
- Continuously improve optical performance
Optical Performance Improvements

• Contrast ratio and black level
  - mirror tilt
  - mirror spacing
  - metallization change

• Color levels/fidelity
  - mirror “flipping” code
  - color wheel implementation

• Reliability

Competition Driven
What Did it Cost

> $MM in R&D annually
  - Basic DMD
  - Associated ASICS
  - System/reference design development
  - Infrastructure development

> $MM in annual capital investment
  - S/C process development
  - Automated testers
  - Advanced manufacturing equipment
A Word On The Brand

- Developed to differentiate from generic LCD “brand”
- Offered customers incentives to use brand on product and in ads
- Helped overcome the unfamiliarity with the technology
- Began the brand development in 1992—it takes time
The Outcome

• High growth in shipments
  - 0 in 1995
  - 500,000 by 2000
  - 1,00,000 by 2002

• Today’s market share is above 30%

• New York Times calls DLP “the technology of choice”

• DLP is in over 150 movie theaters

• DLP HDTV is in over 500 retail stores

• The business is profitable
Some Closing Thoughts

• The device technology that works for R&D runs won’t work for production

• Focus, focus, focus--don’t chase every opportunity because the technology fits

• Find that raison d'être for the technology

• Partner with strong market channels

• Recognize that competitive pressure will require continue product/process improvement (i.e. continued investment)