marlow
industries, inc.

Domestic and International Activities in Thermoelectrics

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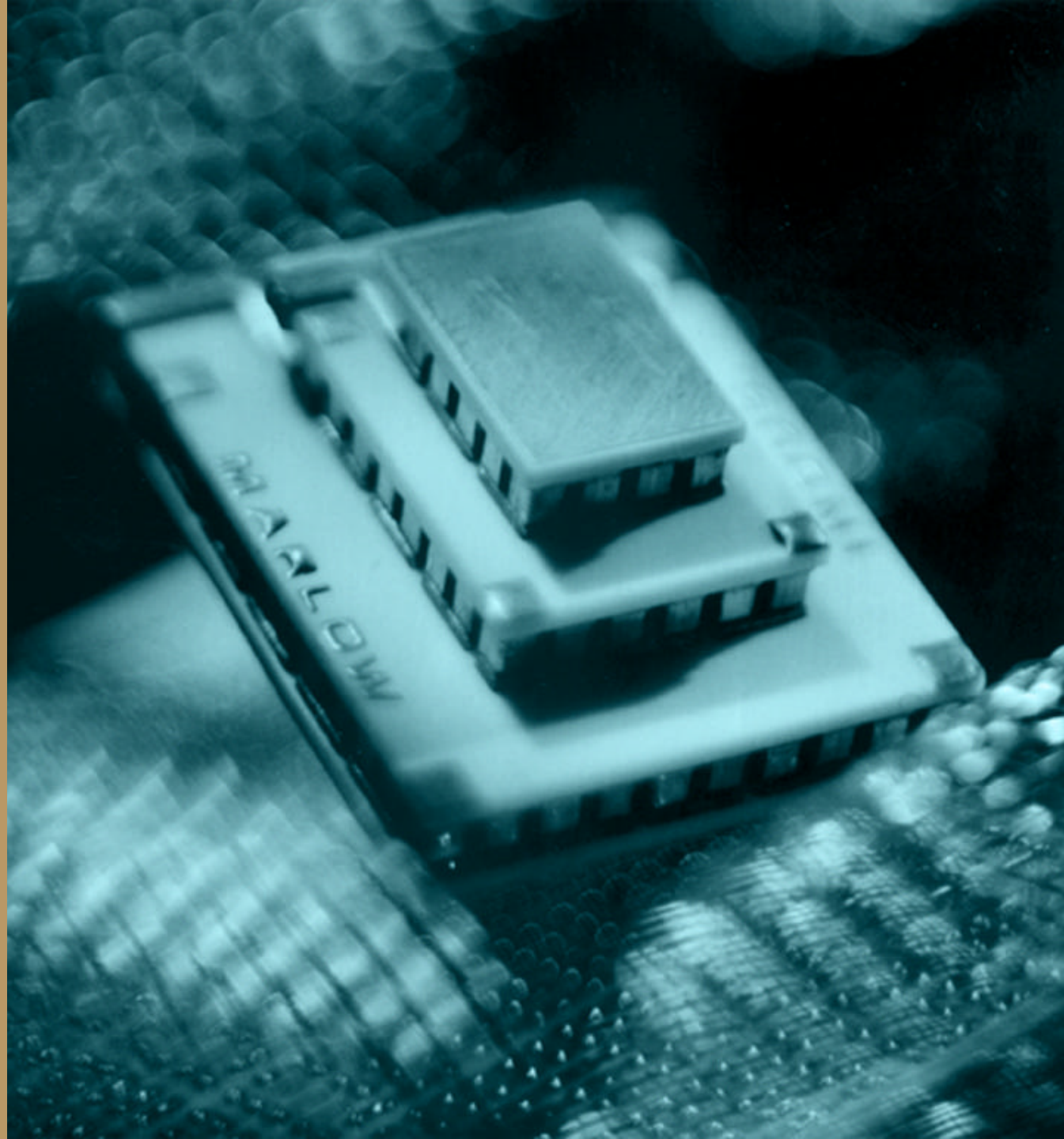


The evolution in bulk materials used in the industry. Domestic

- **Cooling materials**
  - Shift from Zone Refining at the end of the 80's
  - To Bridgman furnace materials early 90's

- Bi_2Te_3 alloys (Sb_2Te_3, Bi_2Te_3 for P and N respectively)

- Higher performance brings with it more fragility.

- Maximum Z values in production Z~2.95 x 10^{-3} 1/T average over the temperature range of use for a couple.

- **Shift by Marlow in 2000 to Micro Alloyed Material (MAM)**
  - Durable
  - More amenable to improvements in manufacturing
  - Highest material figure of merit offered in durable form in world
    - based upon comparative measurements in the Marlow R&D laboratory.
  - No price premium.

The evolution in bulk materials used in the industry. International

- **Japan**
  - Same basic material composition as in US.
  - Long term commitment of Japanese Universities, Industry and Government to improvements in design of devices and material improvements.
  - Emphasis on micro-alloying (ICT papers).
  - Emphasis on power generation materials and devices (ICT papers).
  - Research topics and patent subjects reflect same enterprise interest as US.
- **FSU**
  - Same material composition as US (cooling markets).
  - Very large and dedicated scientific base.
  - St Petersburg, Moscow and Ukraine entities surviving and supplying processed **materials** and devices.
- **Western Europe**
  - Very good research base.
  - Material supply chain similar to US and Japan.

The evolution in devices responding to customers demand. Domestic

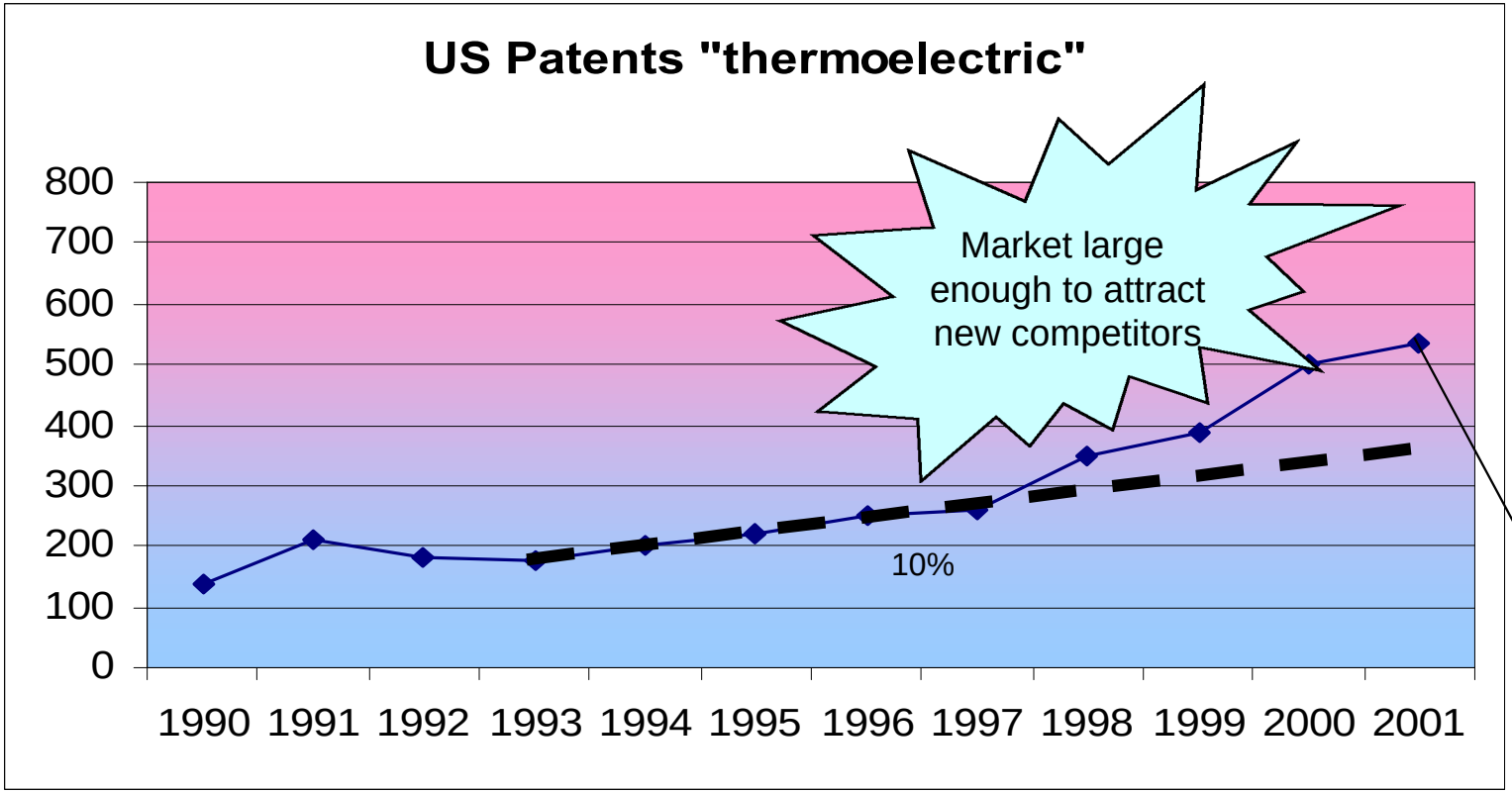
- **Refrigeration**
  - 12 volt DC 30 - 50 Watt cooler picnic box (severe price competition)
- **Electronic/Optical component temperature stabilization/cooling**
  - Special design for high reliability and large temperature difference
- **Medical**
  - PCR cyclers, Blood analyzers, etc.
- **Military**
  - multi stage coolers
- **Niche markets**
  - Ioffe's 30 applications identifiable by the average reader (and more)

The evolution in devices responding to customers demand. International

- **PRC China**
  - Water chillers
    - Domestic market not penetrated by US suppliers.
  - Supplier of low cost picnic boxes, etc. for US market
  - Research activity growing.
  - A growing threat.
- **Japan**
  - Semiconductor cooling (internal consumption)
  - Power generation (HiZ knows best)
  - Large user and supplier of laser diode coolers.
  - Thermoelectric refrigerator manufacture.
  - Wrist Watch powered by thermoelectrics.
- **Europe**
  - Many more niche markets operating.
  - Most markets and products similar to US markets at device level.
  - Creative engineers exploring new applications.
- **FSU**
  - Can’t find a domestic demand, only supply for western markets.

Geographic aspects of the market size

- To the first order the world wide capacity parallels the Patent filings in the US.
- In the period around 1993 the total market was ~ $50,000,000.
- The industry now is in a huge overcapacity situation.



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European Perspective

The European Union has started to get its act together regarding opportunities for thermoelectric research with openings in waste heat recovery and nano technology. These programmes are somewhat like the American system and involve up to 7 institutions, including at least one industrial partner. The budget across the range of technology is very large. The most recent being 17 billion Euros, that is more than 1 billion dollars. Typical budgets for individual projects are about one million dollars and at the moment my group is involved in two with two others being considered.

Regarding progress in thermoelectrics, In Europe segmented and functionally graded materials have been successfully employed in unicouple fabrication and generating performance equal if not better to reported US data. In miniature devices, generators, sensors and coolers, I think probably Europe has the edge, particularly with the work undertaken by Phillips.

The nuclear powered situation in Europe is less clear. A few years ago I undertook analysis for the UK Atomic Energy Authority, assessing the possibilities of constructing a 500 watt isotopic powered thermoelectric generator for possible use by the European space agency. Since then I have not received any further information. I believe work is progressing especially by the French at their aerospace centre near Bordeaux.

It may be worth noting that the Japanese are cementing strong bonds with European researchers.

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