MATERIALS PROCESSING IN SPACE

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ABSTRACT

A brief overview of the current Materials Processing in Space Program will be given, including a tentative schedule of flight experiments. Some recent results of processing materials (e.g., polymers and eutectic materials) in a microgravity environment will be given, along with a discussion on additional proposed flight experiments. Ground-based results and the rationale for flight experimentation will be presented for other materials processes, including crystal growth.

Overall objectives and major areas of research of the Materials Processing in Space Program are shown in figure 1.

MATERIALS PROCESSING IN SPACE (MPS)

GOAL

PROVIDE RESEARCH BASE AND ESTABLISH STS FACILITY USAGE

- O TO ACHIEVE IMPROVED PROCESSING METHODS AND MATERIALS OF TECHNOLOGICAL INTEREST
- O TO ASSIST EARLY COMMERCIALIZATION OF SPACE PROCESSING

CURRENT AREAS OF ACTIVITY

- O CRYSTAL GROWTH
- O SOLIDIFICATION
- O FLUID AND CHEMICAL PROCESSES
- O CONTAINERLESS PROCESSING
- O BIOLOGICAL MATERIALS SEPARATION

Figure 1

Specific areas of research supported by the Materials Processing in Space Program are shown in figure 2.

MPS APPLIED RESEARCH AND DATA ANALYSIS

AREA	THRUST
1. CONTAINERLESS TECHNOLOGY	DEVELOPMENT OF UNIQUE STATE-OF-ART PROCESSING TECHNOLOGY, ACOUSTIC, ELECTROSTATIC, ELECTROMAGNETIC, JET. WE ARE LEADERS IN THIS FIELD.
2. CONTAINERLESS SCIENCE	HIGH-PURITY GLASS NEW OXIDE GLASSES HIGH-TEMPERATURE PROCESSING HIGH-TEMPERATURE THERMOPHYS. MEAS. CORROSIVE REACTIONS BASIC NUCLEATION STUDIES FUSION TARGET TECHNOLOGY
3. CRYSTAL GROWTH	GROWTH FROM VAPOR GROWTH FROM SOLUTION GROWTH FROM MELT
4. SOLIDIFICATION PROCESS	UNDERSTANDING CASTING REDUCING CONVECTIVE EFFECTS IMMISCIBLE MATERIALS COOPERATIVE GROWTH
5. SPACE MATERIALS SYSTEM	DEVELOPMENT OF REQUIREMENTS AND TECHNIQUES FOR EXTRA-TERRESTRIAL MATERIALS PROCESSING
6. BIOLOGICAL PROCESSING	SEPARATION TECHNIQUES SEPARATION OF VIABLE CELLS SEPARATION OF PROTEIN
7. FLUID BEHAVIOR	FLUID DYNAMICS OF SPACE PROCESSING CRITICAL POINT PHENOMENA
8. PROGRAM SUPPORT	SCIENCE AND DISCIPLINE WORKING GROUPS, OUTSIDE PEER REVIEW SUPPORT
9. COMMERCIAL MPS	IDENTIFY COMPANIES AND ARRANGEMENTS FOR COMMERCIALIZATION
10. COMBUSTION	INFLUENCE OF CONVECTION ON COMBUSTION
11. CLOUD PHYSICS	INFLUENCE OF CONVECTION ON CLOUD FORMATION

Figure 2

A chronology of past and proposed flight experiments for the United States Materials Processing in Space Program is shown in figure 3.

FLIGHT EXPERIMENTS

1974 - 1975

- OVER 50 MATERIALS PROCESSING EXPERIMENTS PERFORMED ON SKYLAB AND APOLLO SOYUZ TEST PROGRAM

1982

- 4 RESEARCH EXPERIMENTS
- 1 PRECOMMERCIAL EXPERIMENT

POLYMERIC REACTION STUDIES
ELECTROPHORETIC SEPARATION

1983

- 4 RESEARCH EXPERIMENTS
- 3 PRECOMMERCIAL EXPERIMENTS

POLYMERIC REACTION STUDIES
ELECTROPHORETIC SEPARATION
VAPOR CRYSTAL GROWTH
IMMISCIBLE ALLOY FORMATION
CONTAINERLESS PROCESSING

1984

- 15 RESEARCH EXPERIMENTS
- 3 PRECOMMERCIAL EXPERIMENTS

ELECTROPHORETIC SEPARATION
CONTAINERLESS PROCESSING
UNDERCOOLING/RECALESCENCE STUDIES
VAPOR CRYSTAL GROWTH
IMMISCIBLE ALLOY FORMATION
BLOOD RHEOLOGY
OXIDE GLASS FORMATION
MARANGONI BUBBLE FLOW
SOLUTION CRYSTAL GROWTH

Figure 3

Some applications of results obtained in microgravity investigation to ground-based processing technology are shown in figure 4.

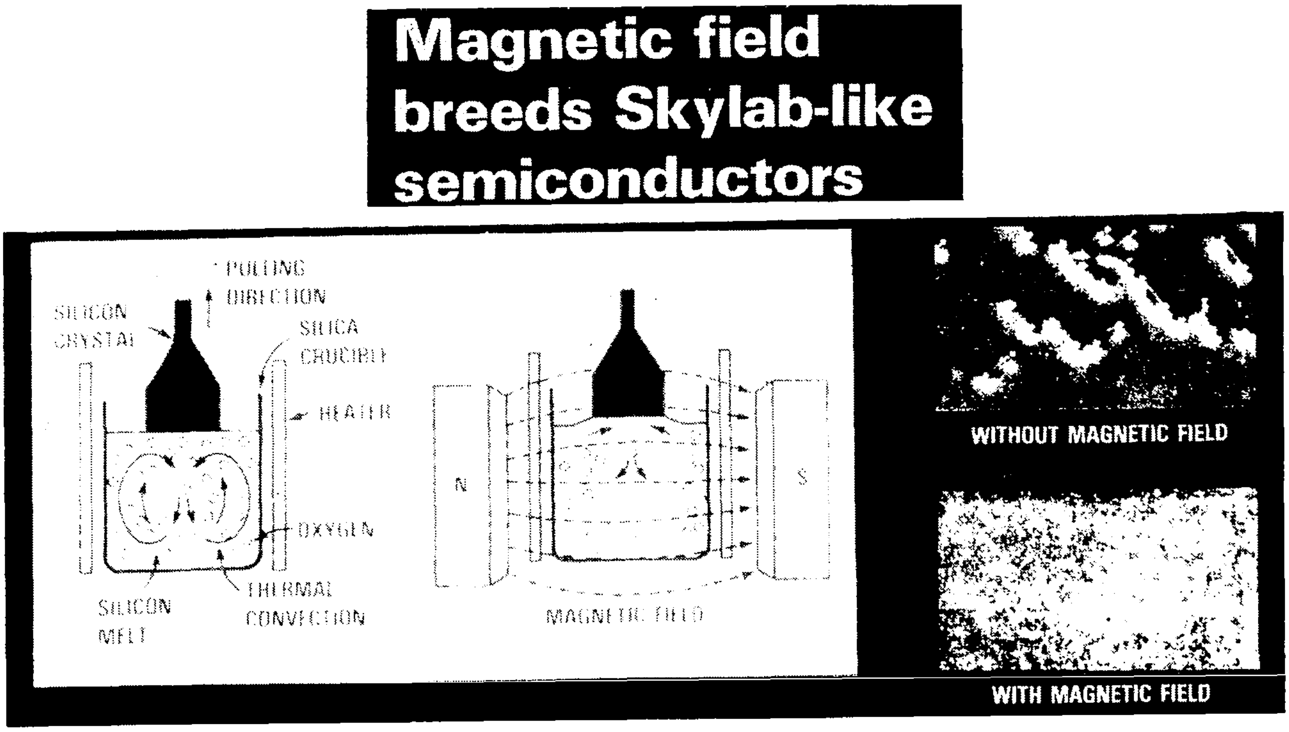

Figure 4

Figure 5 shows a comparison of crystals of HgCdTe grown by vapor transport on Earth. The lower photographs show the results of growing in a vertical thermally stabilizing configuration, while the upper photographs show the results of growing in a horizontal configuration.

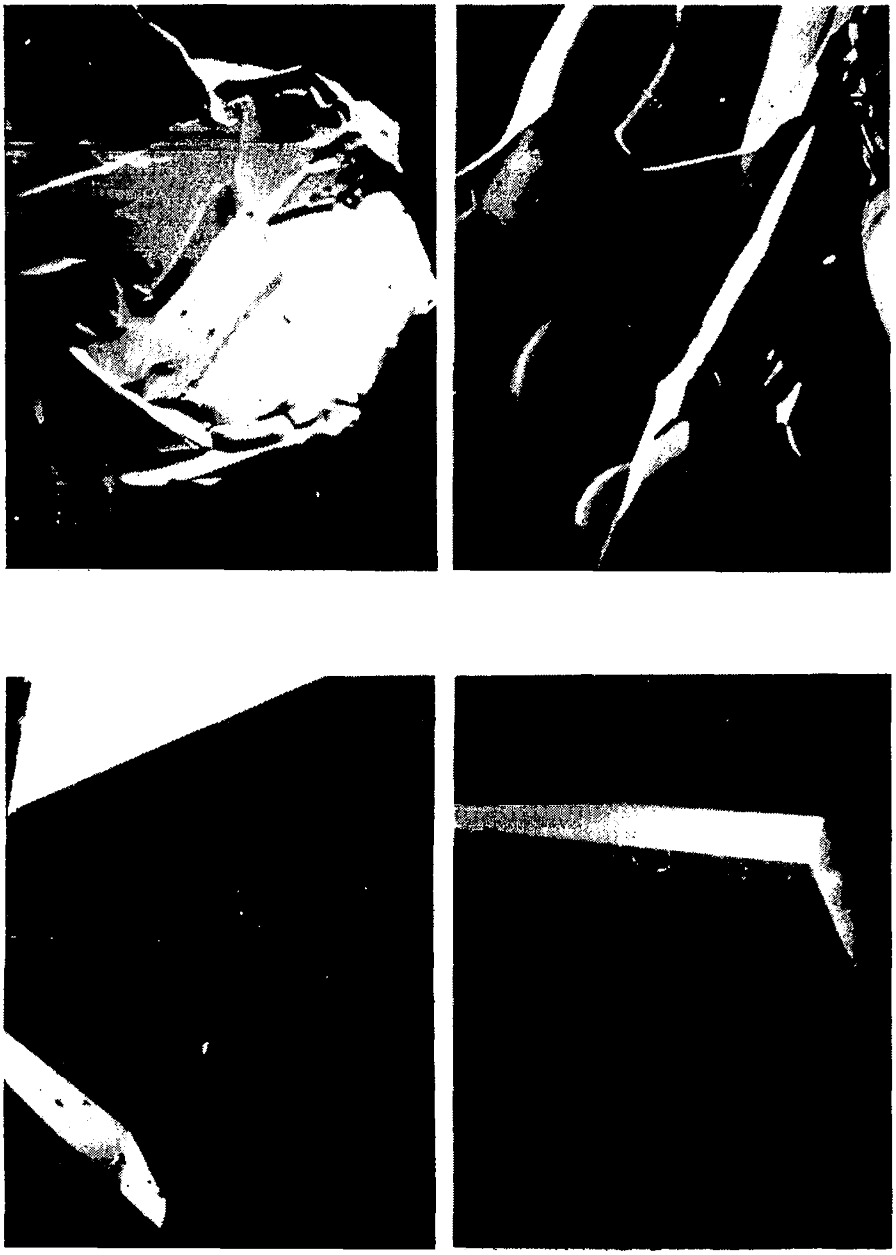

Figure 5

Micrographs of Bi/MnBi eutectic grown under similar conditions are shown in figure 6. The Bi/MnBi was grown in sealed quartz cartridges in a Bridgman-Stockbarger furnace.

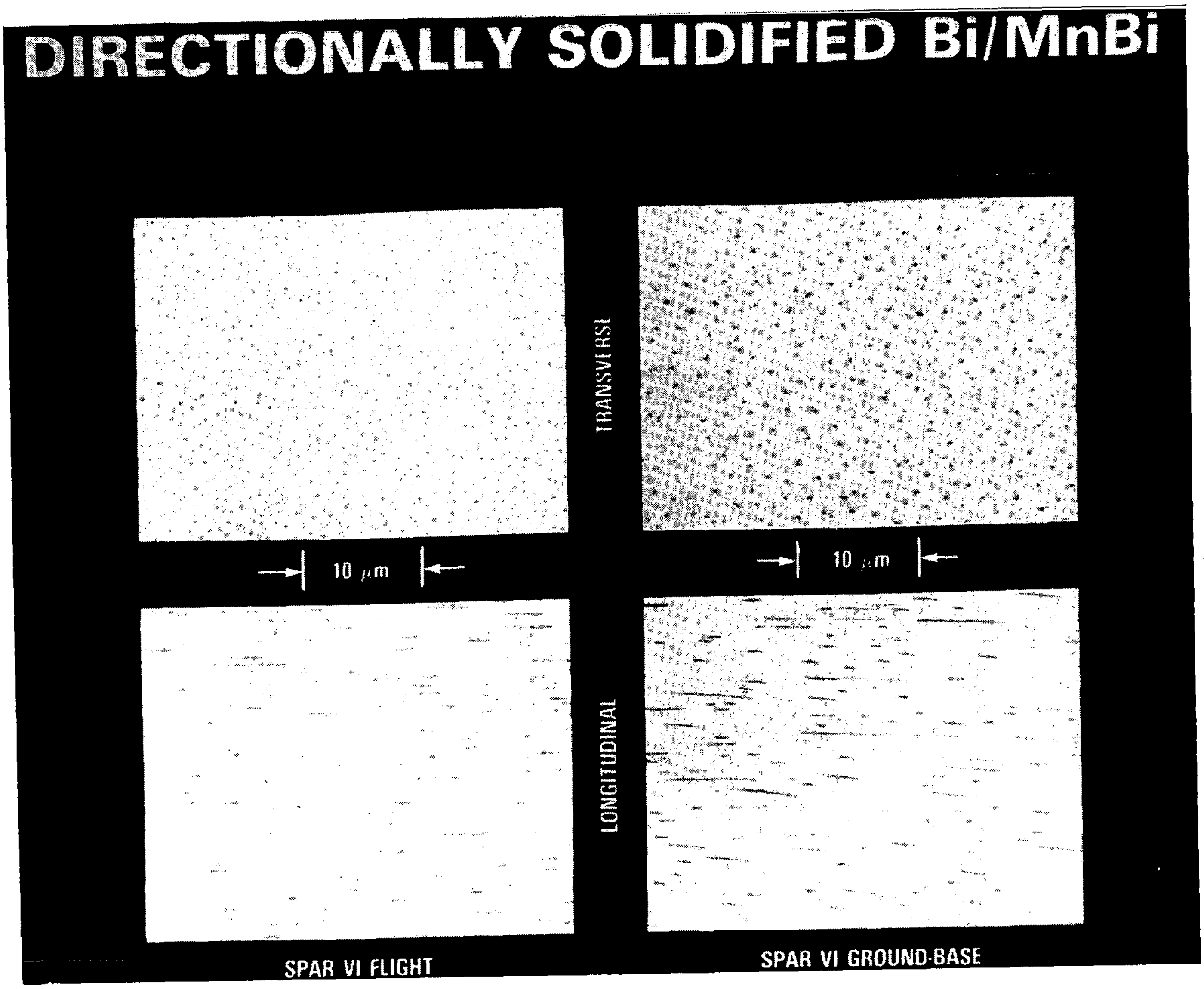

Figure 6

Figure 7 shows a chronology of microgravity separation studies.

PAST

- 1972-73 ELECTROPHORESIS TECHNOLOGY STUDIES - APOLLO
- 1975 STATIC COLUMN ELECTROPHORESIS STUDIES - ASTP

PRESENT

- 1982 PRECOMMERCIAL CONTINUOUS FLOW ELECTROPHORESIS

RECENT RESULTS FROM STS-4

- SEPARATION VOLUME EXCELLENT
- SAMPLE QUANTITY EXTREMELY GOOD
- MOBILITY, SEPARATION UNIMPAIRED

Figure 7

Commercial MPS participants, present and proposed, are shown in figure 8.

COMMERCIAL MPS PARTICIPANTS: PRESENT AND PROPOSED

- JOINT ENDEAVOR AGREEMENT

  INDUSTRY BUILDS HARDWARE WHICH FLIES AS NASA MPS PAYLOAD - NO EXCHANGE OF FUNDS BY NASA - INDUSTRY DERIVES A PRE-COMMERCIAL PRODUCT IN LOW-G ENVIRONMENT OF SPACE

  - MCDONNELL DOUGLAS (SIGNED JANUARY 25, 1980) USES CONTINUOUS FLOW ELECTROPHORESIS APPARATUS TO DEVELOP COMMERCIALLY USEFUL PHARMACEUTICAL MATERIALS
  - GTI CORPORATION - (SIGNED JANUARY 20, 1982) WILL MAKE VARIOUS ALLOYS FOR SALE TO UNIVERSITY AND INDUSTRIAL RESEARCHERS
  - MICROGRAVITY RESEARCH ASSOCIATES, INC. (PROPOSED) WILL GROW GALLIUM ARSENIDE CRYSTALS FOR ELECTRONIC AND COMPUTER APPLICATIONS

- TECHNICAL EXCHANGE AGREEMENT

  PROVIDES FOR SHORT-DURATION LOW-G TIME ON DROP TUBES/ DROP TOWER AND KC-135 - NO EXCHANGE OF FUNDS

  - DEERE AND COMPANY (SIGNED JUNE 29, 1981) EXPLORE PROPERTIES BASIC TO CASTING PROCESS
  - DUPONT (SIGNED JANUARY 27, 1982) EXPLORE CATALYTIC PROPERTIES OF ALLOYS
  - INCO RESEARCH AND DEVELOPMENT CENTER, INC. (SIGNED JANUARY 28, 1982) EXPLORE ELECTROPLATING PROCESS AT LOW-G
  - HONEYWELL ELECTROOPTICAL SYSTEMS STUDY OF MERCURY CADMIUM TELLURIDE

Figure 8