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ANALYSIS OF INCLINED GROWTH OF SILICON SHEET

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Program Goals

- DEVELOP A GENERAL-PURPOSE FINITE ELEMENT PROGRAM FOR ANALYSIS OF SILICON SHEET GROWTH IN INCLINED CONFIGURATIONS. VERIFY ANALYSIS WITH EXPERIMENTAL DATA OF OTHERS.

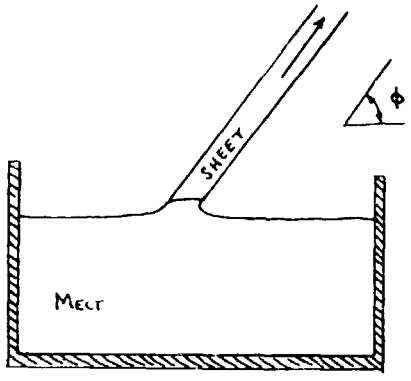
- USE PROGRAM TO STUDY PARAMETRIC SENSITIVITY OF VARIOUS GROWTH GEOMETRIES WITH RESPECT TO:
  - THERMAL CONTROL AND GROWTH RATE
  - DOPANT SEGREGATION
  - THERMAL STRESS
  - INTERFACE MORPHOLOGY AND INSTABILITY

- UNDETERSTAND TRANSITIONS IN INTERFACE MORPHOLOGY AND RELATIONSHIP TO DOPANT SEGREGATION.

Outline

1. THERMAL-CAPILLARY MODELING OF MENISCUS-DEFINED RIBBON-GROWTH
2. PREVIOUS RESULTS FOR EDGE-DEFINED FILM-FED GROWTH
3. PROTOTYPE MODEL FOR INCLINED RIBBON GROWTH
4. CALCULATIONS OF NONLINEAR MORPHOLOGICAL STRUCTURE

Prototype of Inclined Ribbon Growth



SOLUTION INVOLVES DETERMINING

1. TEMPERATURE FIELD IN MELT
2. MELT/CRYSTAL INTERFACE SHAPE
3. MELT/GAS INTERFACE SHAPE
4. CRYSTAL THICKNESS

Complete Analysis of Meniscus-Defined Growth System Required

1. SOLUTION OF ENERGY EQUATIONS IN ALL PHASES (MELT, CRYSTAL, DIE) AND ACCURATE ACCOUNT OF RADIATIVE HEAT TRANSPORT TO SURROUNDINGS
2. DETERMINATION OF MELT/SOLID INTERFACE SHAPE
3. CALCULATION OF MELT/GAS INTERFACE SHAPE TO SATISFY EQUATION OF HYDROSTATICS.
4. CALCULATION OF SHEET THICKNESS TO SATISFY EQUILIBRIUM GROWTH ANGLE.

- DEFINES A VERY COMPLEX NONLINEAR FREE-BOUNDARY PROBLEM. ALGORITHM FOR SOLUTION HAS ALREADY BEEN DEVELOPED.

Strategy for Development of Analysis

- COMPUTER-AIDED CALCULATIONS ARE BASED ON FINITE ELEMENT METHODS DEVELOPED FOR EFG SYSTEM IN COLLABORATION WITH RESEARCHERS AT MOBIL SOLAR ENERGY COMPANY.

- THERMAL STRESS ANALYSIS ALSO BASED ON FINITE ELEMENT SOLUTION OF NONLINEAR EQUATIONS FOR ELASTOPLASTIC DEFORMATION COUPLED WITH THERMAL-CAPILLARY HEAT TRANSFER ANALYSIS.

- COMPARISON WITH EXPERIMENTS WILL INTEGRATE HEAT TRANSFER BOUNDARY CONDITIONS APPROPRIATE FOR PARTICULAR GROWTH CONFIGURATION DIRECTLY INTO THE FINITE ELEMENT ANALYSIS.