



1
00:00:00,000 --> 00:00:35,190

l
2
00:00:35,200 --> 00:00:49,370

Oh

3
00:00:54,930 --> 00:00:52,440
the in-situ monitoring of crystal growth

4
00:00:56,990 --> 00:00:54,940
using Mephisto experiments is a

5
00:00:59,040 --> 00:00:57,000
collaborative American and French

6
00:01:02,630 --> 00:00:59,050
investigation of the fundamentals of

7
00:01:05,640 --> 00:01:02,640
crystal growth the french space agency

8
00:01:09,900 --> 00:01:05,650
cnes and the french nuclear energy

9
00:01:12,240 --> 00:01:09,910
agency ceng designed and built Mephisto

10
00:01:15,389 --> 00:01:12,250
the crystal growth hardware for this

11
00:01:17,639 --> 00:01:15,399
experiment project management and

12
00:01:20,460 --> 00:01:17,649
support functions of the experiments are

13
00:01:24,150 --> 00:01:20,470

provided by personnel of the NASA Lewis

14

00:01:26,310 --> 00:01:24,160

Research Center in Cleveland Ohio the

15

00:01:28,260 --> 00:01:26,320

experiment will fly as part of the

16

00:01:31,770 --> 00:01:28,270

second United States microgravity

17

00:01:35,190 --> 00:01:31,780

payload us mp2 aboard the space shuttle

18

00:01:37,170 --> 00:01:35,200

Columbia the United States principal

19

00:01:40,590 --> 00:01:37,180

investigator for this new Fisto flight

20

00:01:42,660 --> 00:01:40,600

is professor Raisa and las tunas chair

21

00:01:44,730 --> 00:01:42,670

of the Department of material science

22

00:01:47,910 --> 00:01:44,740

and engineering at the University of

23

00:01:50,340 --> 00:01:47,920

Florida the data from this

24

00:01:52,620 --> 00:01:50,350

french-american collaboration will be

25

00:01:56,010 --> 00:01:52,630

analyzed and the scientific information

26
00:01:58,050 --> 00:01:56,020
will be exchanged the knowledge gained

27
00:01:59,760 --> 00:01:58,060
from these experiments will be of

28
00:02:02,850 --> 00:01:59,770
fundamental importance to the

29
00:02:06,990 --> 00:02:02,860
semiconductor industry for the upcoming

30
00:02:09,630 --> 00:02:07,000
US mp2 mission dr. Bastian and his

31
00:02:11,430 --> 00:02:09,640
research team have chosen bismuth with

32
00:02:14,420 --> 00:02:11,440
small amounts of tin to study

33
00:02:16,710 --> 00:02:14,430
solidification and crystal growth

34
00:02:18,840 --> 00:02:16,720
researchers have found that crystals

35
00:02:21,960 --> 00:02:18,850
grown from this alloy possess a

36
00:02:24,330 --> 00:02:21,970
well-behaved Seebeck coefficient this

37
00:02:27,300 --> 00:02:24,340
property of the bismuth tin crystal

38
00:02:29,130 --> 00:02:27,310

allows a non-intrusive real-time

39

00:02:32,819 --> 00:02:29,140

measurement of the solid liquid

40

00:02:34,830 --> 00:02:32,829

interface temperature the measurement of

41

00:02:37,350 --> 00:02:34,840

temperature and other local conditions

42

00:02:39,180 --> 00:02:37,360

at the solid-liquid interface or

43

00:02:42,199 --> 00:02:39,190

boundary between solid and liquid

44

00:02:44,130 --> 00:02:42,209

material are important to scientists in

45

00:02:46,650 --> 00:02:44,140

understanding the structural and

46

00:02:48,059 --> 00:02:46,660

chemical composition of the crystals

47

00:02:51,170 --> 00:02:48,069

that are produced

48

00:02:53,670 --> 00:02:51,180

to illustrate a solid-liquid interface

49

00:02:56,300 --> 00:02:53,680

consider the point at which the solid

50

00:02:59,520 --> 00:02:56,310

wax of a burning candle turns to liquid

51
00:03:01,949 --> 00:02:59,530
the solid liquid interface continues to

52
00:03:06,390 --> 00:03:01,959
move downward as the candle continues to

53
00:03:08,580 --> 00:03:06,400
burn the hardware is mounted on a bridge

54
00:03:12,149 --> 00:03:08,590
like carrier in the space shuttles cargo

55
00:03:14,580 --> 00:03:12,159
bay the french-built mephisto furnace is

56
00:03:16,770 --> 00:03:14,590
designed to grow crystals under well

57
00:03:20,909 --> 00:03:16,780
controlled conditions of temperature and

58
00:03:23,610 --> 00:03:20,919
velocity as the experiment begins the

59
00:03:25,830 --> 00:03:23,620
sample rods are melted the thermal

60
00:03:29,729 --> 00:03:25,840
condition is identical for all three

61
00:03:32,819 --> 00:03:29,739
samples as illustrated here the red

62
00:03:35,189 --> 00:03:32,829
components represent the furnaces while

63
00:03:39,119 --> 00:03:35,199

the blue components represent the heat

64

00:03:41,429 --> 00:03:39,129

sinks or cooling sections the furnace on

65

00:03:43,589 --> 00:03:41,439

the left is stationary while the furnace

66

00:03:47,640 --> 00:03:43,599

on the right is mounted on a sliding

67

00:03:50,189 --> 00:03:47,650

mechanism as the experiment continues

68

00:03:53,429 --> 00:03:50,199

the melted sample rod is slowly

69

00:03:56,069 --> 00:03:53,439

solidified the boundary between the

70

00:03:58,710 --> 00:03:56,079

liquid and solid material or solid

71

00:04:00,809 --> 00:03:58,720

liquid interface occurs between the red

72

00:04:04,530 --> 00:04:00,819

and blue components of the Mephisto

73

00:04:06,899 --> 00:04:04,540

apparatus as the mobile furnace moves

74

00:04:09,869 --> 00:04:06,909

toward the fixed furnace the solid

75

00:04:11,640 --> 00:04:09,879

liquid interface moves also this causes

76
00:04:13,469 --> 00:04:11,650
the temperature of the liquid material

77
00:04:16,800 --> 00:04:13,479
to fall slightly below its freezing

78
00:04:19,259 --> 00:04:16,810
point before solidifying this process

79
00:04:21,300 --> 00:04:19,269
known is supercooling provides a means

80
00:04:24,270 --> 00:04:21,310
of controlling the solidification of the

81
00:04:25,770 --> 00:04:24,280
crystal this is a key variable in

82
00:04:29,010 --> 00:04:25,780
determining the structural composition

83
00:04:30,810 --> 00:04:29,020
of the crystal super cooling is used to

84
00:04:34,170 --> 00:04:30,820
describe the temperature of the

85
00:04:36,990 --> 00:04:34,180
interface when this interface is moving

86
00:04:38,790 --> 00:04:37,000
if the interface is not moving in other

87
00:04:42,209 --> 00:04:38,800
words if you are not growing crystals

88
00:04:44,810 --> 00:04:42,219

the interface temperature is exactly at

89

00:04:47,909 --> 00:04:44,820

the melting point however when the

90

00:04:51,959 --> 00:04:47,919

interface moves its temperature is

91

00:04:54,420 --> 00:04:51,969

slightly below the melting point and the

92

00:04:56,879 --> 00:04:54,430

difference between the actual interface

93

00:04:59,279 --> 00:04:56,889

temperature and the melting point of

94

00:05:01,710 --> 00:04:59,289

that interface is called super cooling

95

00:05:04,680 --> 00:05:01,720

it is actually the driving

96

00:05:07,200 --> 00:05:04,690

force that causes the interface to move

97

00:05:09,810 --> 00:05:07,210

although mephisto processes all three

98

00:05:11,930 --> 00:05:09,820

samples simultaneously different

99

00:05:15,210 --> 00:05:11,940

measurements are taken of each sample

100

00:05:17,490 --> 00:05:15,220

the Seebeck technique is a non intrusive

101
00:05:20,760 --> 00:05:17,500
way of measuring the temperature of the

102
00:05:22,980 --> 00:05:20,770
solid liquid interface a voltage across

103
00:05:25,290 --> 00:05:22,990
the sample is created by a potential

104
00:05:27,480 --> 00:05:25,300
difference between the stationary solid

105
00:05:30,570 --> 00:05:27,490
and liquid interface and the moving

106
00:05:32,520 --> 00:05:30,580
solid and liquid interface the level of

107
00:05:34,980 --> 00:05:32,530
super cooling at the interface in the

108
00:05:37,680 --> 00:05:34,990
moving furnace is determined from this

109
00:05:41,730 --> 00:05:37,690
voltage difference another measurement

110
00:05:43,860 --> 00:05:41,740
is pelletier marking these markings are

111
00:05:47,210 --> 00:05:43,870
created by pulsing an electric current

112
00:05:50,400 --> 00:05:47,220
through the sample this current pulse

113
00:05:52,620 --> 00:05:50,410

causes a momentary change in the local

114

00:05:56,550 --> 00:05:52,630

chemical composition that outlines the

115

00:05:58,850 --> 00:05:56,560

shape of the solid liquid interface by

116

00:06:01,110 --> 00:05:58,860

examining the shape of this interface

117

00:06:03,450 --> 00:06:01,120

scientists can determine the growth

118

00:06:05,760 --> 00:06:03,460

conditions necessary to produce crystals

119

00:06:09,180 --> 00:06:05,770

with fewer imperfections and more

120

00:06:11,730 --> 00:06:09,190

uniform composition at the conclusion of

121

00:06:13,620 --> 00:06:11,740

the experiment the final two centimeters

122

00:06:16,850 --> 00:06:13,630

of one of the melted sample rods is

123

00:06:19,320 --> 00:06:16,860

gassed quenched the quenching

124

00:06:22,409 --> 00:06:19,330

instantaneously freezes the tin in the

125

00:06:25,020 --> 00:06:22,419

liquid the quenched sample can then be

126
00:06:28,320 --> 00:06:25,030
analyzed to determine the at temperature

127
00:06:30,510 --> 00:06:28,330
concentration of tin in the liquid all

128
00:06:32,610 --> 00:06:30,520
this experiment information is

129
00:06:35,700 --> 00:06:32,620
transmitted to the payload operations

130
00:06:38,640 --> 00:06:35,710
control center in real time as it is

131
00:06:41,340 --> 00:06:38,650
happening the principal investigator can

132
00:06:43,620 --> 00:06:41,350
issue commands to adjust or repeat any

133
00:06:46,020 --> 00:06:43,630
segment of the experiment such as

134
00:06:48,630 --> 00:06:46,030
rerunning some of the melting rates when

135
00:06:52,080 --> 00:06:48,640
these experience we hope to learn the

136
00:06:54,659 --> 00:06:52,090
fundamentals that are involved in Salta

137
00:06:56,550 --> 00:06:54,669
fication of crystals you hope to

138
00:06:59,460 --> 00:06:56,560

understand what is happening at the

139

00:07:02,010 --> 00:06:59,470

solid liquid interface and use this

140

00:07:05,640 --> 00:07:02,020

understanding in improving our

141

00:07:08,930 --> 00:07:05,650

scientific and technological basis for

142

00:07:11,010 --> 00:07:08,940

crystal growth so how is all this

143

00:07:14,130 --> 00:07:11,020

experimentation with crystal growth

144

00:07:15,540 --> 00:07:14,140

going to help us here on earth well

145

00:07:18,330 --> 00:07:15,550

since the inception of the

146

00:07:19,730 --> 00:07:18,340

first I'm so sad when people were amazed

147

00:07:22,230 --> 00:07:19,740

by the miracle of wireless

148

00:07:24,600 --> 00:07:22,240

communications the development and

149

00:07:26,730 --> 00:07:24,610

ever-increasing news of crystals has

150

00:07:31,080 --> 00:07:26,740

generated the search for improvement in

151
00:07:34,350 --> 00:07:31,090
crystal quality on earth gravity makes

152
00:07:37,620 --> 00:07:34,360
the growing process more complex non

153
00:07:40,500 --> 00:07:37,630
uniformity defects and voids are common

154
00:07:44,040 --> 00:07:40,510
and results in adverse effects on the

155
00:07:46,560 --> 00:07:44,050
properties of the crystal by growing

156
00:07:49,590 --> 00:07:46,570
crystals in space these earthbound

157
00:07:51,000 --> 00:07:49,600
effects are eliminated we'll have a

158
00:07:52,860 --> 00:07:51,010
better understanding of the growth

159
00:07:55,140 --> 00:07:52,870
process which will enable us to optimize

160
00:07:59,430 --> 00:07:55,150
techniques for growing crystals here on

161
00:08:02,340 --> 00:07:59,440
earth this information translates into

162
00:08:06,060 --> 00:08:02,350
practical uses such as the development

163
00:08:07,950 --> 00:08:06,070

of better semiconductors electrical

164

00:08:10,050 --> 00:08:07,960

circuits are built into the silicon

165

00:08:14,400 --> 00:08:10,060

crystals used in today's solid-state

166

00:08:16,740 --> 00:08:14,410

devices in industry complex machining

167

00:08:19,530 --> 00:08:16,750

operations robotic assembly and

168

00:08:22,920 --> 00:08:19,540

automated inspection are all controlled

169

00:08:25,320 --> 00:08:22,930

by crystal equipped mechanisms in the

170

00:08:27,000 --> 00:08:25,330

medical field new techniques in the

171

00:08:30,360 --> 00:08:27,010

operating rooms are the result of

172

00:08:32,190 --> 00:08:30,370

advances in crystal technology computers

173

00:08:33,900 --> 00:08:32,200

are increasingly faster and more

174

00:08:37,320 --> 00:08:33,910

efficient because of better quality

175

00:08:39,510 --> 00:08:37,330

crystals and today's communications have

176

00:08:43,860 --> 00:08:39,520

come a long way from the first crystal

177

00:08:45,660 --> 00:08:43,870

set this experiment will help to advance

178

00:08:48,810 --> 00:08:45,670

the fundamental knowledge of

179

00:08:51,240 --> 00:08:48,820

solidification and crystal growth it is

180

00:08:54,000 --> 00:08:51,250

a collaborative international exercise

181

00:08:56,340 --> 00:08:54,010

in which the scientific data will be