附件 1　　浙江水利水电学院“南浔学者”申请表

<table>
<tr><td>姓　　名</td><td>史立秋</td><td>出生年月</td><td>1978 年 7月</td><td>参加工作时间</td><td>2001 年 9 月</td></tr>
<tr><td>现所在单位(部门)</td><td>机械学院</td><td>最高学历/学位</td><td>研究生/博士</td><td>专业技术职务</td><td>教授</td></tr>
<tr><td>拟申报类别</td><td colspan="5">二类学者</td></tr>
<tr><td>符合条款</td><td colspan="5">符合二类学者业绩成果（1）5 类期刊论文 5 篇。（2）主持国家级、省部级教学科研纵向项目 5 项：III 类项国家自然科学基金项目 1 项，Ⅵ类项目省自然科学基金项目 2 项，省级课程思政教学项目 1 项，省新世纪优秀人才项目 1 项。</td></tr>
<tr><td rowspan="8">所涉业绩</td><td rowspan="2">教学类
绩点：30</td><td colspan="4">省级课程思政教学项目 1 项（30）</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="2">科研类
绩点：400</td><td colspan="4">省自然科学基金 2 项（60）+国家基金 1 项（150）+省新世纪优秀人才 1 项（30）</td></tr>
<tr><td colspan="4">SCI 论文 5 篇（100）+ B 类专著 1 本（60）</td></tr>
<tr><td rowspan="2">人才称号类
绩点：_____</td><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="2">与上述水平相当的其他业绩</td><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td>总绩点</td><td colspan="4">430</td></tr>
<tr><td colspan="5">备注：请严格按照《浙江水利水电学院“南浔学者”实施办法（试行）》（浙水院〔2022〕113 号）附件《业绩成果绩点赋值项目库》的类目、分类、等级（等次）、绩点填写。</td></tr>
<tr><td>个人承诺</td><td colspan="5">本人承诺上述所填内容真实、准确；如有不实，本人承担相应责任。
签名：史立秋　　时间：2023.11.16</td></tr>
<tr><td colspan="6">以上部分由申请人填写，所在单位审核。以下由单位（部门）和学校填写。</td></tr>
<tr><td>所在单位
（部门）意见</td><td colspan="5">1.经审核，申请人所填内容：☐属实　　☐不属实；
2.是否符合所申请的类别：☐符合　☐不符合；
3.是否同意推荐：☐同意　☐不同意。
负责人签名：　　（部门盖章）
____年____月____日</td></tr>
<tr><td>科技处审核
意见</td><td colspan="2">负责人签名：　　（部门盖章）
年___月___日</td><td>教务处审核
意见</td><td colspan="2">负责人签名：　　（部门盖章）
年___月___日</td></tr>
<tr><td>其他相关职能
部门审核意见</td><td colspan="5">负责人签名：　　（部门盖章）
_____年____月____日</td></tr>
<tr><td>学校意见</td><td colspan="5">（学校盖章）
____年____月____日</td></tr>
</table>

备注：表格请用 A4 纸打印，有关佐证材料附后。

佐证材料清单

序号	项目、论文、著作类别	项目名称	时间	排名
1	**省自然科学基金**	短链芳香烃介导机械-化学方法实现硅基底DNA探针制备新技术及其机理	**2022.12**	**主持**
2	**省级课程思政教学研究项目**	大思政背景下《机械制造技术》课程思政探索	**2022.9**	**主持**
3	**省自然科学基金**	单晶硅表面功能性微纳结构制造技术研究	**2019.12**	**主持**
4	**国家自然科学基金**	基于机械-化学方法的硅表面功能性跨尺度结构形成机理研究	**2015.4**	**主持**
5	**省高校新世纪优秀人才项目**	单晶硅表面改性技术研究	**2017.12**	**主持**
6	**5 类 SCI 论文**	Fabrication of Multiscale 1-Octadecene Monolayer Patterned Arrays Based on a Chemomechanical Method	**2022.5**	**第一**
7	**5 类 SCI 论文**	A new method for determining necking of thin metal sheets based on main strain topography	**2023.11**	**第一** **（已录用）**
8	**5 类 SCI 论文**	Connection of ssDNA to Silicon Substrate Based Mechano- Chemical Method	**2023.5**	**第一**
9	**5 类 SCI 论文**	Preparation of Aryldiazonium Salt Monolayers on Si(100) Surface by Chemomechanical Method. Chinese Journal of Chemical Physics	**2012.1**	**第一**
10	**5 类 SCI 论文**	Fabrication of Functional Structures at Si (100) surface by Mechanical Scribing in the Presence of Aryl Diazonium Salts	**2010.1**	**第一**
11	**B 类专著**	单晶硅超精密加工技术仿真	**2020.4**	**独著**

1. 省自然科学基金项目计划书：

浙江省基础公益研究计划项目批准通知

史立秋同志：

根据浙江省自然科学基金相关管理规定，浙江省自然科学基金委员会会同相关部门决定资助您申请的以下项目：

项目批准号	LY20E050012		依托单位	浙江水利水电学院	
项目名称	短链芳香烃介导机械-化学方法实现硅基底 DNA 探针制备新技术及其机理				
项目负责人	史立秋		证件号码	230803197807010021	
项目类别	省自然科学基金/探索项目 Y		研究期限	2020 年 1 月 至 2022 年 12 月	
总经费（万元）	9.00	省财政资助经费（万元）	9.00	联合资助经费(万元)	0.00

序号	其他主要成员	证件号码	性别	单位名称
1	李祉宏	360702198809160615	男	浙江水利水电学院
2	冯燕	330481198501110041	女	浙江水利水电学院
3	陈光	23080319750727704X	女	台州学院
4	张强	230103198508140316	男	哈尔滨工业大学
5	谭荣凯	362202199012197612	男	哈尔滨工业大学
6	张瑞涛	340122199605060018	男	哈尔滨工业大学

浙江省自然科学基金委员会办公室

2019 年 11 月 19 日

2. 省级课程思政教学研究项目：

附件

2022年省级课程思政教学项目拟立项名单

（二）2022年省级课程思政教学研究项目拟立项名单

序号	项目名称	项目负责人	项目其他主要成员	所属学校
266	一流本科教育背景下“多方同行”的新工科课程思政内涵挖掘和实施路径探索	黄春芳	慈艳柯、王景丽、胡晔、张育斌	宁波财经学院
267	基于“艺 ·工”融合的《结构素描》 课程思政教学改革探索与实践	漆菁夫	刘岚、梁伟、漆小平、王楠	宁波财经学院
268	基于OBE理念的大学物理课程思政教育教学模式的探索和实践	陈健	蔡亦良、黄世娟、张羽溪、刘晓萍	浙江水利水电学院
269	大思政背景下《机械制造技术》课程思政探索	史立秋	方贵盛、孙培峰、徐高欢、陈仙明	浙江水利水电学院
270	外语思政思政视阈下大学生批判性思辨能力的培养	张妍瑜	杨昆、张林凤、胡晓梅、林西鹤	浙江水利水电学院
271	融合水文化的《泵与泵站》课程思政KPC模式的探索与实践	刘振华	邢雅娟、徐栋、吴淑云、陈爱朝	浙江水利水电学院
272	课程思政视域下中国古诗词歌曲的教学实践研究	王洁	王小天、朱洁琼、董海燕、易丹丹	浙江音乐学院
273	高校声乐课程思政教学内容与模式研究	陈建彬	董海燕、吴明	浙江音乐学院

3. 省自然科学基金项目：

浙江省基础公益研究计划项目验收证明

史立秋同志：

根据浙江省基础公益研究计划项目相关管理规定及项目验收情况，准予您承担的以下项目验收通过。

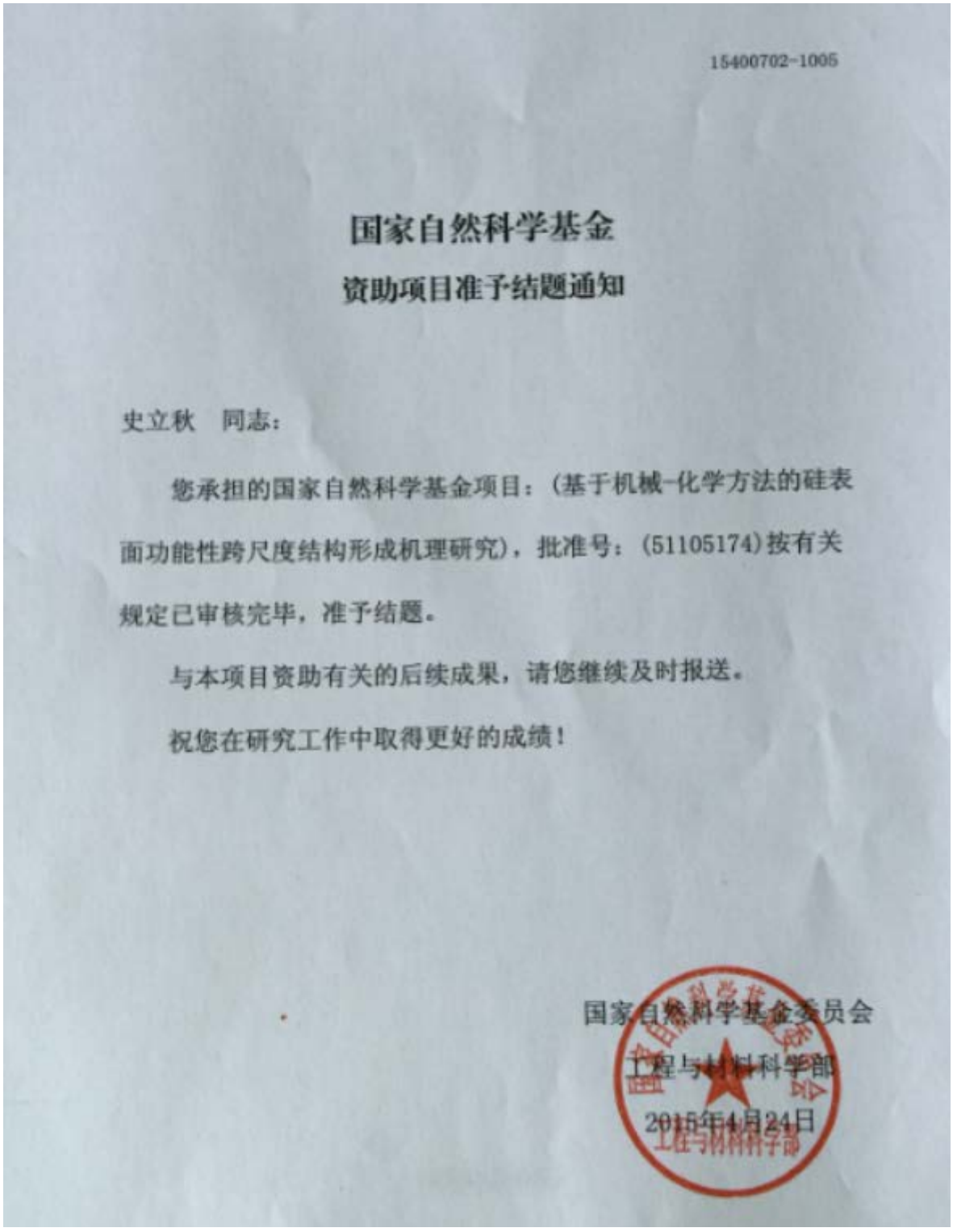
项目批准号	LY20E050012		依托单位	浙江水利水电学院	
项目名称	短链芳香烃介导机械-化学方法实现硅基底DNA探针制备新技术及其机理				
项目负责人	史立秋		证件号码	230803197807010021	
项目类别	省自然科学基金/探索项目/探索一般		研究期限	2020-01-01至2022-12-31	
总经费（万元）	9	省财政资助经费(万元)	9	联合方资助经费（万元）	0

浙江省自然科学基金委员会办公室

2023年4月3日

项目管理专用章

4. 国家自然科学基金项目：



15400702-1005

国家自然科学基金

资助项目准予结题通知

史立秋　同志：

您承担的国家自然科学基金项目：（基于机械-化学方法的硅表面功能性跨尺度结构形成机理研究），批准号：（51105174）按有关规定已审核完毕，准予结题。

与本项目资助有关的后续成果，请您继续及时报送。

祝您在研究工作中取得更好的成绩！

国家自然科学基金委员会

工程与材料科学部

2015年4月24日

5. 省高校新世纪优秀人才项目：

新世纪优秀人才培养计划入选者

总结报告

（资助期限：2014 年 01 月至 2016 年 12 月）

批　准　号：1254--NCET—022

姓　　名：史立秋

研 究 领 域：超精密加工及微纳制造

所 在 学 校：佳木斯大学

通 讯 地 址：佳木斯大学学府路 148 号

联 系 电 话：13904547866

编 写 日 期：2017-06-15

黑龙江省教育厅制

所在高等学校学术委员会审查意见

《单晶硅表面改性技术研究》是一个具有交叉性、创新性的科研项目，选题目的明确，科学意义重大，研究方案合理，技术路线可行。

项目申请人在课题研究期间完成了预期规定的目标，先后主持国家自然科学基金1项、省自然科学基金1项，参与国家自然科学基金1项；发表论文3篇，出版独著1部，获批实用新型专利2项。

学术委员会研究同意该项目结题。

学术委员会主任（签字）

（学校公章）

2017 年 6 月 20 日

所在高等学校意见

同意结题。

（盖章）

2017 年 6 月 20 日

教育厅意见

经审查，该项目完成预期成果，同意结题。

科研项目验收专用章

（盖章）

2017 年 7 月 7 日

6. SCI 论文：Fabrication of Multiscale 1-Octadecene Monolayer Patterned Arrays Based on a Chemomechanical Method

processes

MDPI

Article

Fabrication of Multiscale 1-Octadecene Monolayer Patterned Arrays Based on a Chemomechanical Method

Liqiu Shi [1,2,*], Feng Yu [1] and Zhouming Hang [1,2]

[1] School of Mechanical and Automotive Engineering, Zhejiang University of Water Resources and Electric Power, Hangzhou 310018, China; jmsdxyf@163.com (F.Y.); hangzhm@zjweu.edu.cn (Z.H.)
[2] Key Laboratory for Technology in Rural Water Management of Zhejiang Province, Zhejiang Engineering Research Center for Advanced Hydraulic Equipment, Hangzhou 310018, China
* Correspondence: jmsdxshiliqiu@163.com

Abstract: A controlled and self-assembled micromachining system was built to fabricate a mico/nanoscale monolayer patterned array on a silicon surface using a diamond tip. The process was as follows: (1) we preprocessed a silicon wafer to obtain a hydrogen-terminated silicon surface; (2) we scratched three rectangular arrays of 10 μm × 3 μm with a spacing of 2 μm on the silicon surface with a diamond tip in 1-octadecene solution; the Si-H bonds were broken, and silicon free radicals were formed; (3) the 1-octadecene molecules were connected with silicon atoms based on Si-C covalent bonds, and the 1-octadecene nano monolayer was self-assembled on the patterned arrays of the silicon surface. Atomic force microscopy (AFM), X-ray photoelectron spectroscopy (XPS), and Sessile water contact angles were used to detect and characterize the self-assembled monolayers (SAMs). The XPS results showed that the Si2p peak and the O1s peak were significantly decreased after self-assembly; however, the C1s peak was successively significantly increased. Sessile water contact angles showed that the hydrophilicity was weakened after the formation of 1-octenecene SAMs on the silicon substrate. The nanofriction of the sample was measured with AFM. The change in nanofriction also demonstrated that the SAMs were formed in accordance with the patterned array. We demonstrated that, by using this method, self-assembled multiscale structures on silicon substrate can be formed quickly and conveniently.

Keywords: silicon; self-assembly; 1-octadecene; chemomechanical method

Citation: Shi, L.; Yu, F.; Hang, Z. Fabrication of Multiscale 1-Octadecene Monolayer Patterned Arrays Based on a Chemomechanical Method. *Processes* **2022**, *10*, 1090. https://doi.org/10.3390/pr10061090

Academic Editor: Luis Puigjaner

Received: 28 April 2022
Accepted: 26 May 2022
Published: 30 May 2022

1. Introduction

Silicon has become the most important material in the microelectronics industry [1–4]. When exposed to air, the silicon surface can be quickly oxidized. This oxide layer induces electron defect states and electron flow resistance, which jeopardizes the material's performance [5]. Removing the oxide layer of the silicon surface and reforming a new Si-H surface can significantly enhance its electrical performance [6]. However, the Si-H surface can also be quickly oxidized when exposed to air, which leads to rapid performance degradation. Therefore, many attempts have been made to graft organic molecules onto a silicon surface, in order to stabilize, improve, and control the properties of the silicon surface. Khung et al. [7] studied the thermal grafting properties of nucleophilic aniline on the surface of planar Si (111) through XPS analysis and AFM characterization. FTIR and Sessile water contact angles were used to verify the proposed theory and results. Eihadj et al. [8] grafted organic molecules to modify the silicon surface. The process was carried out by electrochemical reduction of 4-nitrobenzene diazonium tetrafluoroborate in an aqueous medium containing HF and H_2SO_4. It appears that the cathodic grafting led to the formation of a polymeric layer, but the same grafting also occurred spontaneously within a few tens of seconds at the open circuit potential, an expected phenomenon in view of the reduction potential of 4-nitrobenzene diazonium. Eihadj et al. [8] modified

Clarivate Analytics

论文检索报告

SCI-E 收录

根据Liqiu Shi提供的论文目录检索Web of Science ™ 核心合集，其发表论文被 SCI-E 收录文献 1 篇（检索时间2022年6月5日）。

检索结果：被 SCI-E 收录文献 1 篇

#	作者	标题	来源出版物	JCR影响因子	JCR分区	出版物类型	入藏号
1	Shi, LQ; Yu, F; Hang, ZM	Fabrication of Multiscale 1-Octadecene Monolayer Patterned Arrays Based on a Chemomechanical Method	*PROCESSES* 2022, 10 (6): 1090.	• 3.352 (2021);	• ENGINEERING, CHEMICAL [Q2] (2021);	J Article	WOS:000816132600001
						合计	1

备注	影响因子/期刊分区的年份选择：最新年份

收录文献附录

第 1 条，共 1 条：
出版物类型：J
文献类型：Article
标题：Fabrication of Multiscale 1-Octadecene Monolayer Patterned Arrays Based on a Chemomechanical Method
作者：Shi, LQ (Shi, Liqiu); Yu, F (Yu, Feng); Hang, ZM (Hang, Zhouming)
作者地址：[Shi, Liqiu; Yu, Feng; Hang, Zhouming] Zhejiang Univ Water Resources & Elect Power, Sch Mech & Automot Engn, Hangzhou 310018, Peoples R China.; [Shi, Liqiu; Hang, Zhouming] Zhejiang Engn Res Ctr Adv Hydraul Equipment, Key Lab Technol Rural Water Management Zhejiang P, Hangzhou 310018, Peoples R China.
通讯作者地址：Shi, LQ (通讯作者)，Zhejiang Univ Water Resources & Elect Power, Sch Mech & Automot Engn, Hangzhou 310018, Peoples R China.; Shi, LQ (通讯作者)，Zhejiang Engn Res Ctr Adv Hydraul Equipment, Key Lab Technol Rural Water Management Zhejiang P, Hangzhou 310018, Peoples R China.
来源出版物：PROCESSES　卷：10　期：6　文献号：1090　出版年：2022　出版时间：JUN
入藏号：WOS:000816132600001
电子邮件地址：jmsdxshiliqiu@163.com; jmsdxyf@163.com; hangzhm@zjweu.edu.cn
eISSN: 2227-9717
IDS 号：2K1VT
基金资助机构和授权号：Zhejiang Provincial Natural Science Foundation of China [LY20E050012]; Scientific Research Foundation of Zhejiang University of Water Resources and Electric Power [xky2022041]; Key Laboratory for Technology in Rural Water Management of Zhejiang Province [ZJWEU-RWM-20200301A]; Zhejiang Public Welfare Technology Application Research Project [LGF21D020002]; Key Technology Research and Development Program of Zhejiang [2021C03019]
基金资助正文：This research was funded by the Zhejiang Provincial Natural Science Foundation of China, grant number LY20E050012, the Scientific Research Foundation of Zhejiang University of Water Resources and Electric Power, grant number xky2022041, the Key Laboratory for Technology in Rural Water Management of Zhejiang Province, grant number ZJWEU-RWM-20200301A, the Zhejiang Public Welfare Technology Application Research Project, grant number LGF21D020002, and the Key Technology Research and Development Program of Zhejiang, grant number 2021C03019.
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出版商城市：BASEL
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Web of Science 学科分类：Engineering, Chemical
Web of Science 研究方向：Engineering
JCR 影响因子：

期刊	JCR 影响因子	指标年份
PROCESSES	3.352	2021

JCR 期刊分区：

数据库	JCR 类别	JCR 分区	指标年份
SCIE	ENGINEERING, CHEMICAL	Q2	2021

7. SCI 论文：A new method for determining necking of thin metal sheets based on main strain topography （已录用，待发表）

materials MDPI

Article

A new method for determining necking of thin metal sheets based on main strain topography

Liqiu Shi[1,2*], Yingjie Yang[1], Lin Zhang[3], Bo Hou[1,2], Lingen Zhu[3], Yan Feng[1], and Zhouming Hang[1,2]

[1] School of Mechanical and Automotive Engineering, Zhejiang University of Water Resources and Electric Power, Hangzhou 310018, P. R. China; jmsdxshiliqiu@163.com
[2] Key Laboratory for Technology in Rural Water Management of Zhejiang Province, Zhejiang Engineering Research Center for Advanced Hydraulic Equipment, Hangzhou 310018, P. R. China
[3] College of Mechanical Engineering, Jiamusi University, Jiamusi 154007, P. R. China
* Correspondence: jmsdxshiliqiu@163.com

Abstract: There are various methods to evaluate the forming limit of a sheet, and these criteria can be classified as position-dependent, time-dependent, and position-time dependent according to the basis of judgment. However, these criteria have a single function and can only find the forming limit of the sheet and cannot describe the strain distribution, strain change, and fracture location during the sheet forming process. This paper introduces a time-location dependent method: the spatial strain rate method, which is used to detect the onset of necking of the sheet. The spatial strain rate is directly based on the strain and can not only find the forming limit of the sheet but also depict the strain distribution and strain variation during the two phases of the experimental process: distributed instability and concentrated instability, as well as predict the location of the sheet fracture. The spatial strain rate of AA5083 aluminum alloy of different widths was analyzed and verified in detail by Nakazima experiments using digital image correlation techniques, and compared with the guidelines published in the literature in recent years.

Keywords: Forming limit; Spatial strain rate; Time location correlation method; Nakazima experiment;

Citation: Lastname, F.; Lastname, F.; Lastname, F. Title. *Processes* **2022**, *10*, x. https://doi.org/10.3390/xxxxx

Academic Editor: Firstname Lastname

Received: date
Accepted: date
Published: date

1. Introduction

Formability assessment of metal sheets is important for optimal design and development of advanced forming technologies. Necking is the most common failure phenomenon in the forming and manufacturing of sheet metal [1]. Before 2008, there was no clear method to determine the forming limit of metal materials [2]. With the demand of the industry a generalized standard was developed internationally to guide the industry production ISO 12004-2:2008 [3], this method has too many limitations and has not been unanimously accepted internationally, the time dependent method proposed by Eberle et al. [4] is still in the standardization stage. Based on this situation, researchers from various countries have proposed their own judgment guidelines for experimental determination, but none of them have found a general method for determining the forming limit diagram (FLD) of materials, and how to accurately find the forming limit of materials has developed into a hot issue in today's research. Hill [5] pioneered the criterion of local necking under planar stress conditions. This criterion was applied to obtain the left side of the FLC. For the right side, Swift [6] proposed that instability occurs when the principal stress reaches a maximum size and predicted the critical strain for diffuse necking. The most widely used analytical tool is the Marciniak-Kuczynski (M-K) model [7]. This is based on the hypothetical theory that necking is caused by the initial defect. In biaxial tension, the onset of necking is associated with the establishment of a local plane strain state at the defect perpendicular to the principal strain direction. Later, Hutchinson

8. SCI 论文：Connection of ssDNA to Silicon Substrate Based Mechano-Chemical Method

micromachines

MDPI

Article

Connection of ssDNA to Silicon Substrate Based on a Mechano–Chemical Method

Liqiu Shi [1,2,*], Feng Yu [1], Mingming Ding [1,2], Zhouming Hang [1,2], Yan Feng [1], Aifang Yan [1] and Hongji Dong [1]

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Abstract: A novel fabrication process to connect single-stranded DNA (ssDNA)to a silicon substrate based on a mechano–chemical method is proposed. In this method, the single crystal silicon substrate was mechanically scribed in a diazonium solution of benzoic acid using a diamond tip which formed silicon free radicals. These combined covalently with organic molecules of diazonium benzoic acid contained in the solution to form self-assembled films (SAMs). The SAMs were characterized and analyzed by AFM, X-ray photoelectron spectroscopy and infrared spectroscopy. The results showed that the self-assembled films were covalently connected to the silicon substrate by Si–C. In this way, a nano-level benzoic acid coupling layer was self-assembled on the scribed area of the silicon substrate. The ssDNA was further covalently connected to the silicon surface by the coupling layer. Fluorescence microscopy showed that ssDNA had been connected, and the influence of ssDNA concentration on the fixation effect was studied. The fluorescence brightness gradually increased with the gradual increase in ssDNA concentration from 5 µmol/L to 15 µmol/L, indicating that the fixed amount of ssDNA increased. However, when the concentration of ssDNA increased from 15 µmol/L to 20 µmol/L, the detected fluorescence brightness decreased, indicating that the hybridization amount decreased. The reason may be related to the spatial arrangement of DNA and the electrostatic repulsion between DNA molecules. It was also found that ssDNA junctions on the silicon surface were not very uniform, which was related to many factors, such as the inhomogeneity of the self-assembled coupling layer, the multi-step experimental operation and the pH value of the fixation solution.

Keywords: mechano–chemical method; single crystal silicon; diazo salt of benzoic acid; coupling layer; ssDNA

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1. Introduction

In the construction of DNA biosensors and the manufacture of DNA chips, the effective fixation of DNA probe on the surface of the converter or carrier is an important basic premise. Therefore, the research on DNA fixation has important guiding significance for the improvement of sensor and chip technology [1–3]. Typical methods of DNA probe fixation include adsorption, SAM (self-assembling film), and covalent bonding. Among them, the SAM method and covalent bonding method can produce a stable modification layer and improve the firmness and durability of the probe [4–7]. Fang et al. [8] self-assembled amino thiols on the surface of a gold electrode to introduce amino groups. In the presence of a chemical coupling activator, water-soluble carbodiimide (EDC), the probe DNA molecules were covalently fixed on the electrode surface through a condensation reaction. Mirsky et al. [9] used a gold electrode modified with alkyl thiols to covalently fix NH_2–DNA and studied the influence of different fixation conditions on the fixation density. The self-grouping covalent fixation method of the gold surface does not require special

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9. SCI 论文： Preparation of Aryldiazonium Salt Monolayers on Si(100) Surface by Chemomechanical Method. Chinese Journal of Chemical Physics

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ARTICLE

Preparation of Aryldiazonium Salt Monolayers on Si(100) Surface by Chemomechanical Method

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Functionalizing and patterning of the silicon surface can be realized simultaneously by the chemomechanical method. The oxide-coated crystalline silicon (100) surface is scratched with a diamond tool in the presence of aryldiazonium salt ($C_6H_5N_2BF_4$). Scratching activates the silicon surface by removing the passivation oxide layer to expose fresh Si atoms. The surface morphologies before and after chemomechanical reaction are characterized with atomic force microscopy. Time-of-flight secondary ion mass spectroscopy confirms the presence of C_6H_5 and provides evidence for the formation of self-assembled monolayer (SAM) on silicon surface via Si−C covalent bonds by scratching the silicon in the presence of $C_6H_5N_2BF_4$. C_6H_5 groups further bond with surface Si atoms via Si−C covalent bonds as confirmed from infrared spectroscopy results. We propose that chemomechanical reaction, which occurred during scratching the silicon surface, produce C_6H_5 groups from aryldiazonium salt. The relevant adhesion of SAM is measured. It is found that SAM can reduce the adhesion of silicon. The monolayer can be used as anti-adhesion monolayer for micro/nanoelectromechanical systems components under different environments and operating conditions.

Key words: Chemomechanical, Silicon, Monolayer, Aryldiazonium salt

I. INTRODUCTION

Traditionally, fabrications of silicon-based devices require complex processes. An alternative approach by the combination of convenient mechanical fabrication and chemical treatment is of great importance. During last few years, chemomechanical modification of silicon has emerged as a simple and convenient approach for simultaneously functionalizating and patterning silicon surfaces [1−6]. Generally, the steps of chemomechanical surface functionalization with a diamond tool are: (i) An oxide terminated silicon substrate is prepared. (ii) The surface is scribed with the system in the presence of a reactive compound. (iii) The unreacted compound is removed. We hypothesize that the mechanism of formation of the new monolayer on silicon is closely related to the reaction of aryldiazonium salts with highly active surface species, bare silicon.

When an oxide-coated silicon surface is scribed, Si−Si or Si−O bonds are mechanically broken, producing a chemically active surface that reacts with a variety of molecules, covalently binding them directly to a crystalline silicon substrate [7]. This procedure takes place in an open laboratory with compounds that have not been degassed to otherwise specially treated. Scratched silicon is already known to react with 1-alkenes [8], 1-alkynes [9], aldehydes [10], epoxides [11], and acid chlorides [12].

The chemomechanical method was used to modify the silicon surface to form self-assembled monolayers in the presence of aryldiazonium salt ($C_6H_5N_2BF_4$). The aryldiazonium salt solution, because of the rich and versatile chemistry of activated aryl groups, can modify silicon surface and produce functional self-assembled monolayer (SAM) to connect Si atoms with other molecules [13−15]. The functionalizing and patterning silicon surface can be realized simultaneously. Time-of-flight secondary ion mass spectroscopy (TOF-SIMS), Fourier transform infrartd spectroscopy (FTIR), and atomic force microscopy (AFM) were used to characterize the samples. Adhesive force of oxide-coated Si(100) surface and phenyl-terminated monolayer was measured using AFM.

II. EXPERIMENTS

A. Sample preparation and handling

All sample preparations were carried out in the air at room temperature with compounds that had not been degassed. Si(100) wafers (p-boron, 460±15 μm, test grade) were used and bought from Shenzhen. All chemicals were analytical grade and used as received. Super pure water was obtained by Milli-Q water sys-

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附件一：SCIE 收录情况：

第 1 条，共 1 条

标题: Preparation of Aryldiazonium Salt Monolayers on Si(100) Surface by Chemomechanical Method

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摘要: Functionalizing and patterning of the silicon surface can be realized simultaneously by the chemomechanical method. The oxide-coated crystalline silicon (100) surface is scratched with a diamond tool in the presence of aryldiazonium salt (C(6)H(5)N(2)BF(4)). Scratching activates the silicon surface by removing the passivation oxide layer to expose fresh Si atoms. The surface morphologies before and after chemomechanical reaction are characterized with atomic force microscopy. Time-of-flight secondary ion mass spectroscopy confirms the presence of C(6)H(5) and provides evidence for the formation of self-assembled monolayer (SAM) on silicon surface via Si-C covalent bonds by scratching the silicon in the presence of C(6)H(5)N(2)BF(4). C(6)H(5) groups further bond with surface Si atoms via Si-C covalent bonds as confirmed from infrared spectroscopy results. We propose that chemomechanical reaction, which occurred during scratching the silicon surface, produce C(6)H(5) groups from aryldiazonium salt. The relevant adhesion of SAM is measured. It is found that SAM can reduce the adhesion of silicon. The monolayer can be used as anti-adhesion monolayer for micro/nanoelectromechanical systems components under different environments and operating conditions.

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10. SCI 论文： Fabrication of Functional Structures at Si (100) surface by Mechanical Scribing in the Presence of Aryl Diazonium Salts

Fabrication of functional structures at Si (100) surface by mechanical scribing in the presence of aryl diazonium salts

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A combination of chemical and mechanical method has been proposed to fabricate modified surface on the oxide-coated silicon. When the diamond tool scribes the silicon sample in the presence of 4-benzoic acid diazonium tetrafluoroborate ($COOHC_6H_4N_2BF_4$), the chemoactive $COOHC_6H_4$ radical can be generated from aryldiazonium salt due to the breaking of chemical bond of silicon substrate. They may then induce grafting of an organic monolayer on the substrate via Si–C connection. The surface morphologies before and after chemomechanical reaction are characterized with atomic force microscopy. X-ray photoelectron spectroscopy confirms the presence of $COOHC_6H_4$ and shows a steady increase in the amount of carbon on the exposed fresh Si surface. Infrared spectroscopy suggests that $COOHC_6H_4$ groups bond with surface Si atoms via Si–C covalent bonds. To the best of the authors knowledge, this is the first report of the chemomechanical preparation of self-assembled monolayers on oxide-coated silicon in the presence of aryldiazonium salt. The method described in this article will have important implications for building nano- or microscale functional structures. © *2009 American Vacuum Society.* [DOI: 10.1116/1.3137025]

I. INTRODUCTION

Silicon has been made one of the most important of all materials because of the rapid growth of the semiconductor and microelectronics industries. Traditionally, fabrications of silicon-based devices require complex processes. Providing an alternative approach by the combination of convenient mechanical fabrication and chemical treatment is of great importance. For the past few years, chemomechanical modification of silicon has emerged as a simple and convenient approach for simultaneously functionalizing and patterning silicon surfaces.[1–6] When an oxide-coated crystalline silicon surface is scribed with a hard scribes like a diamond tool, Si–Si or Si–O bonds are broken mechanically. The resulting chemically active surface can react covalently with a variety of molecules.[7] The aromatic diazonium salts, because of its wide variety of unsubstituted or substituted aromatic radicals, appears to be a general and versatile agent for modifying silicon surfaces.[8–10]

Here, for the first time in the presence of 4-benzoic acid diazonium tetrafluoroborate ($COOHC_6H_4N_2BF_4$), we report that the chemomechanical method can be used to modify the silicon surface to form self-assembled monolayers (SAMs). We found that functionalizing and patterning silicon surface can be realized simultaneously. X-ray photoelectron spectroscopy (XPS), fast Fourier infrared (FTIR), and atomic force microscopy (AFM) are used to characterize the samples. To explain the formation of monolayers on scribed silicon from aryldiazonium salt, a two-step mechanism was proposed, as shown in Fig. 1.[11] In the first step, the one-electron reduction in the arenediazonium salt forms an arene radical. In the second step, the arene radical bonds covalently via C–Si bond to exposed reactive Si atoms to form SAMs.

II. EXPERIMENTAL SECTION

The steps of chemomechanical surface functionalizing with a diamond tool are (1) preparation of the oxide-terminated silicon substrate, (2) scribing of the sample in the

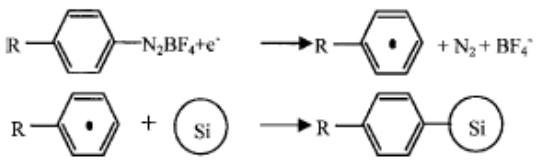

FIG. 1. Stepwise attachment of an arenediazonium salt to silicon.

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拟方法进行了简单介绍，讨论确定了模拟的初始条件，并建立了单晶硅纳米切削的三维仿真模型；第 7 章硅表面超精密切削的分子动力学仿真与分析，使用 LAMMPS 软件并借助分子动力学方法来进行仿真计算，在三维图像中从原子瞬时位置、温度和原子间势能等方面探讨单晶硅切削过程中材料去除方式与已加工表面的成形机理；第 8 章加工参数对硅表面切削过程的影响，主要研究切削深度、切削速度、刀尖几何形状和刀具前角等几方面因素的影响。

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尽管著者为本书付出了十分的心血和努力，但书中难免存在一些疏漏和欠妥之处，敬请广大读者批评指正。

史立秋

2020 年 4 月