Production of superhydrophobic copper surfaces by fabricating micro-nano features using wet etching process

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ABSTRACT

Superhydrophobic surfaces receive many applications in various industries such as desalination, heat exchanger, anti-fog and self-cleaning surface production. In this study a wet etching process was used to produce superhydrophobic copper surfaces. The specimens were etched by multiple ferric chloride and deionized water solutions to create micro-nano structures on their surfaces. The electronic scanning electron microscopy (SEM) images of the resulted surfaces show a formation of micro-nano structures with specific templates. Contact and sliding angle measurement of surfaces after etching process showed that contact angles of specimens increased to nearly 140° while sliding angle of all samples was 180°, which is the same as a rose petal property. In the next step, to promote hydrophobicity of surfaces, increased contact angle and decreased sliding angle specimen were immersed in an ethanol and stearic acid solution with a specific concentration. Moreover, effects of etching time and etchant concentration on the sliding and contact angles with/without stearic acid modification were investigated. Results show that contact angles increased and sliding angles decreased remarkably so that it reduced to lower than 10° in some cases and lotus effect was achieved.

1. Introduction

Superhydrophobic surfaces have received many applications in various industries such as desalination, heat exchanger, anti-fog and self-cleaning surface production. In this study, a wet etching process was used to produce superhydrophobic copper surfaces. The specimens were etched by multiple ferric chloride and deionized water solutions to create micro-nano structures on their surfaces. The electronic scanning electron microscopy (SEM) images of the resulted surfaces show a formation of micro-nano structures with specific templates. Contact and sliding angle measurement of surfaces after etching process showed that contact angles of specimens increased to nearly 140° while sliding angle of all samples was 180°, which is the same as a rose petal property. In the next step, to promote hydrophobicity of surfaces, increased contact angle and decreased sliding angle specimen were immersed in an ethanol and stearic acid solution with a specific concentration. Moreover, effects of etching time and etchant concentration on the sliding and contact angles with/without stearic acid modification were investigated. Results show that contact angles increased and sliding angles decreased remarkably so that it reduced to lower than 10° in some cases and lotus effect was achieved.

2. Materials and Methods

The copper plates used in this study were purchased from the local market. The copper plates were polished using 180, 320, 600, 800, and 1200 grit sand papers. The polished copper plates were then cleaned in deionized water and dried in a fume hood. The copper plates were then etched in a solution of ferric chloride and deionized water for different periods of time. The concentration of the ferric chloride solution was 10% and the concentration of the deionized water solution was 90%. The temperature of the etching solution was maintained at 25°C. The etching process was performed for 15, 30, 45, and 60 minutes. After etching, the copper plates were washed with deionized water and dried in a fume hood.

3. Results and Discussion

The SEM images of the resulted surfaces show a formation of micro-nano structures with specific templates. The contact angles of the specimens increased to nearly 140° while sliding angle of all samples was 180°, which is the same as a rose petal property. In the next step, to promote hydrophobicity of surfaces, increased contact angle and decreased sliding angle specimen were immersed in an ethanol and stearic acid solution with a specific concentration. Moreover, effects of etching time and etchant concentration on the sliding and contact angles with/without stearic acid modification were investigated. Results show that contact angles increased and sliding angles decreased remarkably so that it reduced to lower than 10° in some cases and lotus effect was achieved.

4. Conclusion

In conclusion, the wet etching process was used to produce superhydrophobic copper surfaces. The contact angles of the specimens increased to nearly 140° while sliding angle of all samples was 180°, which is the same as a rose petal property. In the next step, to promote hydrophobicity of surfaces, increased contact angle and decreased sliding angle specimen were immersed in an ethanol and stearic acid solution with a specific concentration. Moreover, effects of etching time and etchant concentration on the sliding and contact angles with/without stearic acid modification were investigated. Results show that contact angles increased and sliding angles decreased remarkably so that it reduced to lower than 10° in some cases and lotus effect was achieved.

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Chemical etching

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wire electrical discharge machining (WEDM)

adhesion (Cassie-Baxter regime) [12].

Cassie-impregnation regime

Fig. 2 Schematic of droplet configurations on superhydrophobic surfaces with high adhesion (Cassie impregnation regime) or low adhesion (Cassie-Baxter regime) [12].

Cassie-Baxter regime

Fig. 1 Schematic of a) Sliding angle b) Contact angle [14].

(a)

(b)

390
۱- ادامه نمونه
در این تحقیق نمونه‌های زیر از میکرو فلورسنت، پایین و بدون تغییر خلوص استفاده شده است.

با توجه به استانداردهای ایجاد شده در مراکز ملی و بین‌المللی، استفاده از روش‌های تحقیقی و شیمیایی در این تحقیق به منظور ارتقای کیفیت تحقیق و شناسی انجام شده است.

۲- انواع آزمایش

۱) مایعات آزمایش

اصلی‌ترین مشخصه‌های این مایعات می‌تواند تأثیر قابل توجهی در کاهش خطر به‌دست آمده از میکروورسیون و بهبود عملکرد سیستم تحت نابودی‌های مختلف باشد.

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انسیملاک محدودیت‌های وجود داشته و محدودیت‌های مصرف توده‌های کلروراینی 12 کریستال و 18 کریستال کروشیل است قرارگیری بزرگ در فضای نسبتاً بزرگ شیار ترین مولکول‌های توده‌های کلروراینی شکل داده و مولکول‌های کروشیل بر به صورت کیت بهبودی به صورت خراش صفحه اسپار می‌توانند به

ترتبی استاترکس اسید ضمن کاهش انرژی سطحی، خاصیت آب‌گریزی به

به‌پوده می‌دهد (36).

در مواد به‌دیری باعث تغییر بهینه زمان قرار گرفتن نمونه در محلول،

چهار نمونه در مدت زمان‌های 5، 15 و 60 ساعت در محلول با غلظت بهینه

با استفاده از بقیه (نسبت به 4 ک فرصت آن همان 3 به دو بیست

قرار داده شد. شکل 4 نشان این را نشان می‌دهد. شکل 4

مدت زمان 5 ساعت قرارگیری نمونه در محلول را نشان می‌دهد.

داده را از تاکم می‌باشد.

همچنین شکل 4 نشان داده است، اسید را بر

افزایش ایجاد نمود نشان می‌دهد. این این که

تغییر می‌تواند با افزایش زمان افزایش و

باید برای هر روشی محلول 90 بیشتر، زاویه لغزش

کوثری داشته باشد، زاویه لغزش کوثری حاصل می‌شود.

همچنین با افزایش زمان کارزینوم نمونه در محلول، میزان لغزش

کاهش می‌یابد بطوری که برای نمونه‌ها که به مدت 15 ساعت در محلول با

شکل 5 قطعات قرار گرفته روی سطح را نشان می‌دهد. این نتیجه

یک‌گان این اسید در حالت عادی استفاده از استاترکس اسید و منتها

با محلول کلرید آهن 3 خاصیت آب‌گریزی (راوی ناس اسید کمتر از 150

روی سطح ایجاد می‌شود) 21 حالت گرمایشی در حالت اسیداز است، استاترکس اسید خاصیت آب‌گریزی از توده‌های نیازی است.

ایجاد شد استفاده از استاترکس اسید غلظت باعث افزایش راوه ناس می‌نماید. منجر به

کاهش شدید زاویه لغزش شد و در حین آمیخته و منتها کریتی نتایج مشاهده

شد برای همین نمونه‌ها با شرایط محلول مختلط زمان و غلظت محلول که در آن از

Fig. 4 variation of contact angles versus immersion time for a constant concentration of etchant of [1:4] شکل 4 تعیینات اسید نسبت به زمان‌های مختلف غلظتی در محلول خودنی (اثر استفاده از استاترکس اسید) - در غلظت نسبت به 4 محلول خودنی (اثر استفاده از استاترکس اسید)

392

Fig. 5 Schematic of droplets on the etched surfaces with concentration [1:4] and time immersion time 5 hr for a) without stearic acid b) with stearic acid (droplet volume, 5µL.) شکل 5 تغییرات زاویه لغزش برای حالت‌های با و بدون استفاده از استاترکس اسید

نسبت به غلظتی مختلف محلول خودنی (در مدت زمان تابع گرافیک 2 ساعت)

5 Carboxyl group
Fig. 6 droplet configuration at various surface positions of a upside down

Fig. 7 variation of sliding angles versus immersion time

Fig. 8 The SEM image with 500 magnifications of copper surfaces etched for a) 1h b) 4h c) 5h, etched by concentration [1:4] of etchant solution

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Fig. 9 The SEM image with 2000 magnifications of copper surfaces etched for a) 1h b) 5h, etched by concentration [1:4] of etchant solution.

Fig. 10 The SEM image with 10000 magnifications of copper surfaces etched for 5h, etched by an etchant solution with concentration [1:4]...


