

ヘテロ表面ダイによるしごき加工性の向上



豊橋技科大 安部 洋平



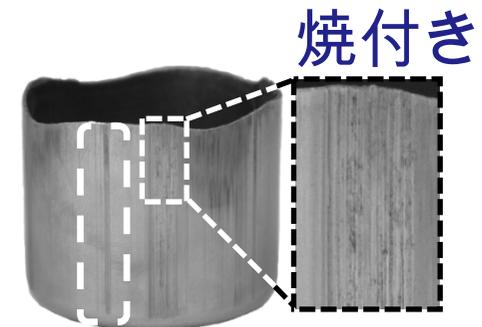
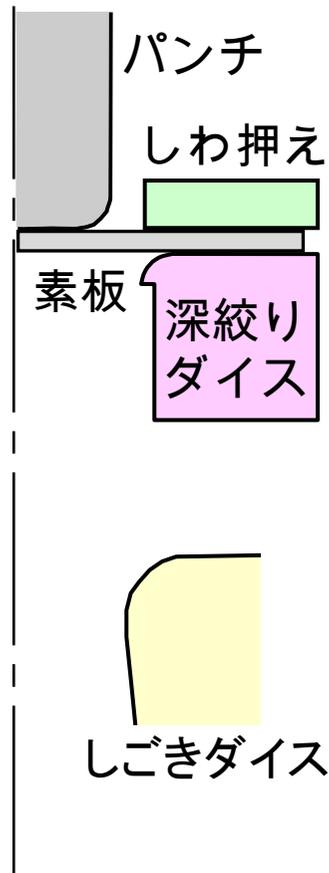
電気自動車



二次電池用ケース

ステンレス鋼板

しごき加工



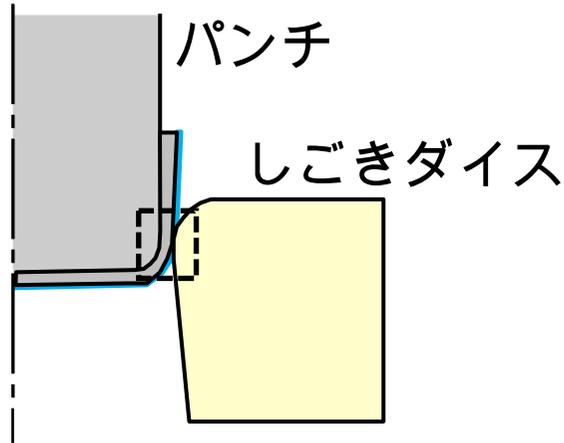
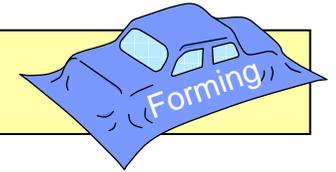
(a) 工具鋼SKD11



(b) TiCNサーメット

TiCNサーメットダイスは耐焼付き性が高く有効

ヘテロ表面サーメットダイ



しごき加工後容器

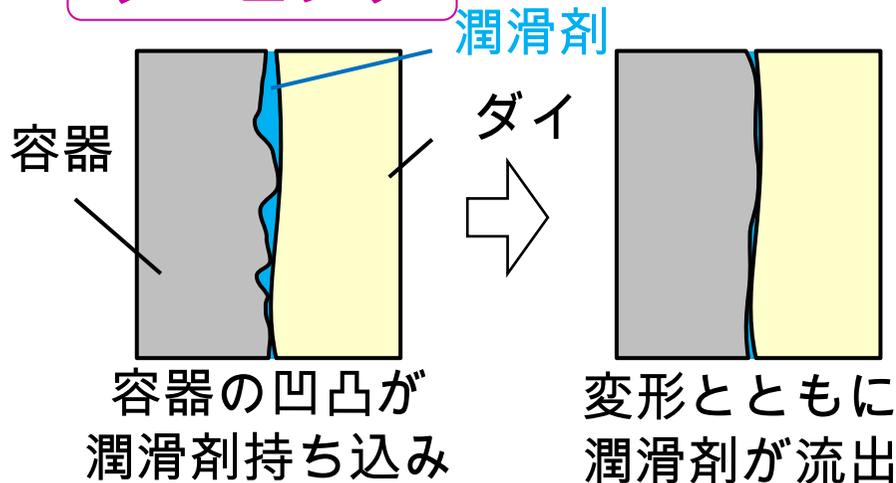


(a) ラッピング

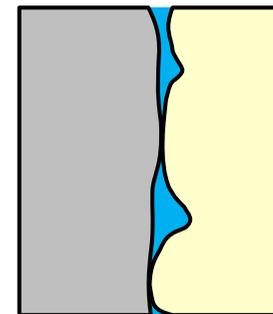


(b) ヘテロ表面

ラッピング



ヘテロ表面

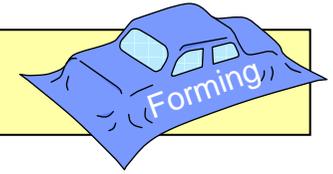


ダイ表面にくぼみ

潤滑剤保持

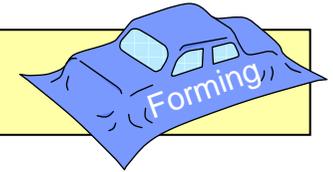
目的: TiCNサーメットヘテロ表面ダイによる加工性の向上

目次



- ヘテロ表面サーメットダイとしごき加工条件
- ヘテロ表面ダイのしごき加工
- 潤滑メカニズム

深絞り容器のしごき加工条件



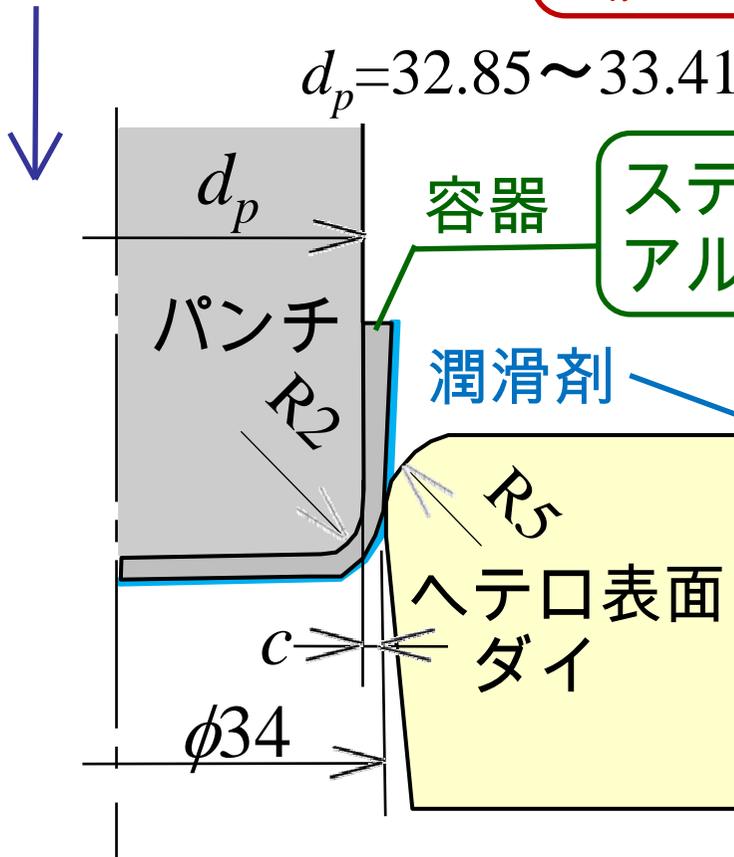
パンチ速度
 $v=50\sim 150\text{mm/s}$

公称しごき率

$$r_n = 10\sim 50\%$$

$d_p = 32.85\sim 33.41\text{mm}$

板厚 0.6mm



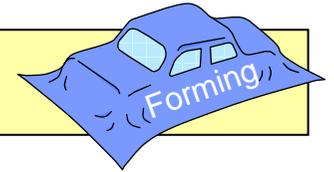
容器
 ステンレス鋼 : SUS430, SUS304
 アルミニウム合金 : A3003-O

潤滑剤

SUS:塩素系極圧添加剤あり
 低粘度潤滑剤($2.9\text{mm}^2/\text{s}$)
 A3003:極圧添加剤なし
 高粘度潤滑剤($562\text{mm}^2/\text{s}$)

材料	引張強さ [MPa]	伸び [%]	n値	r値	硬さ [HV5]
SUS430	547	25.7	0.20	1.17	167

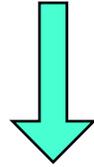
ダイ製作プロセス



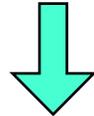
ダイ材料

TiCNサーメット

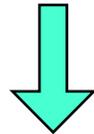
放電加工



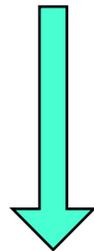
研削



ラッピング



ショットピーニング



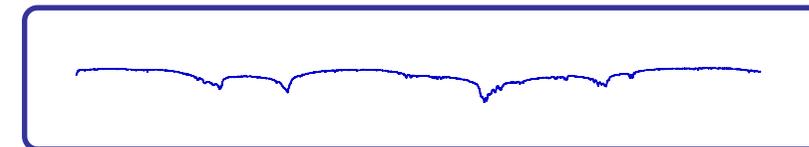
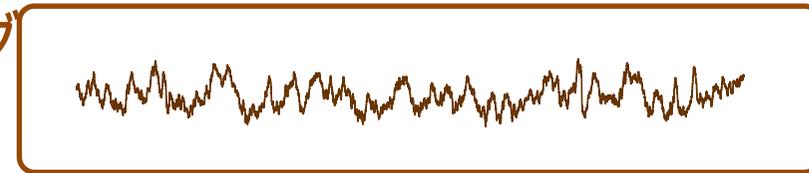
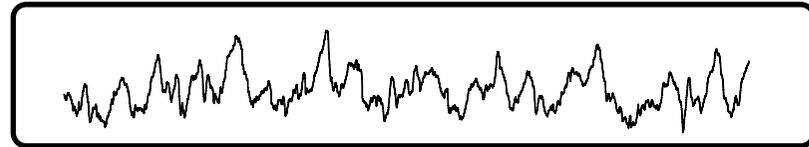
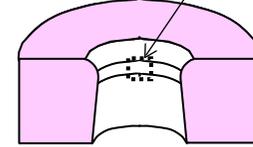
ヘテロ表面

研磨処理

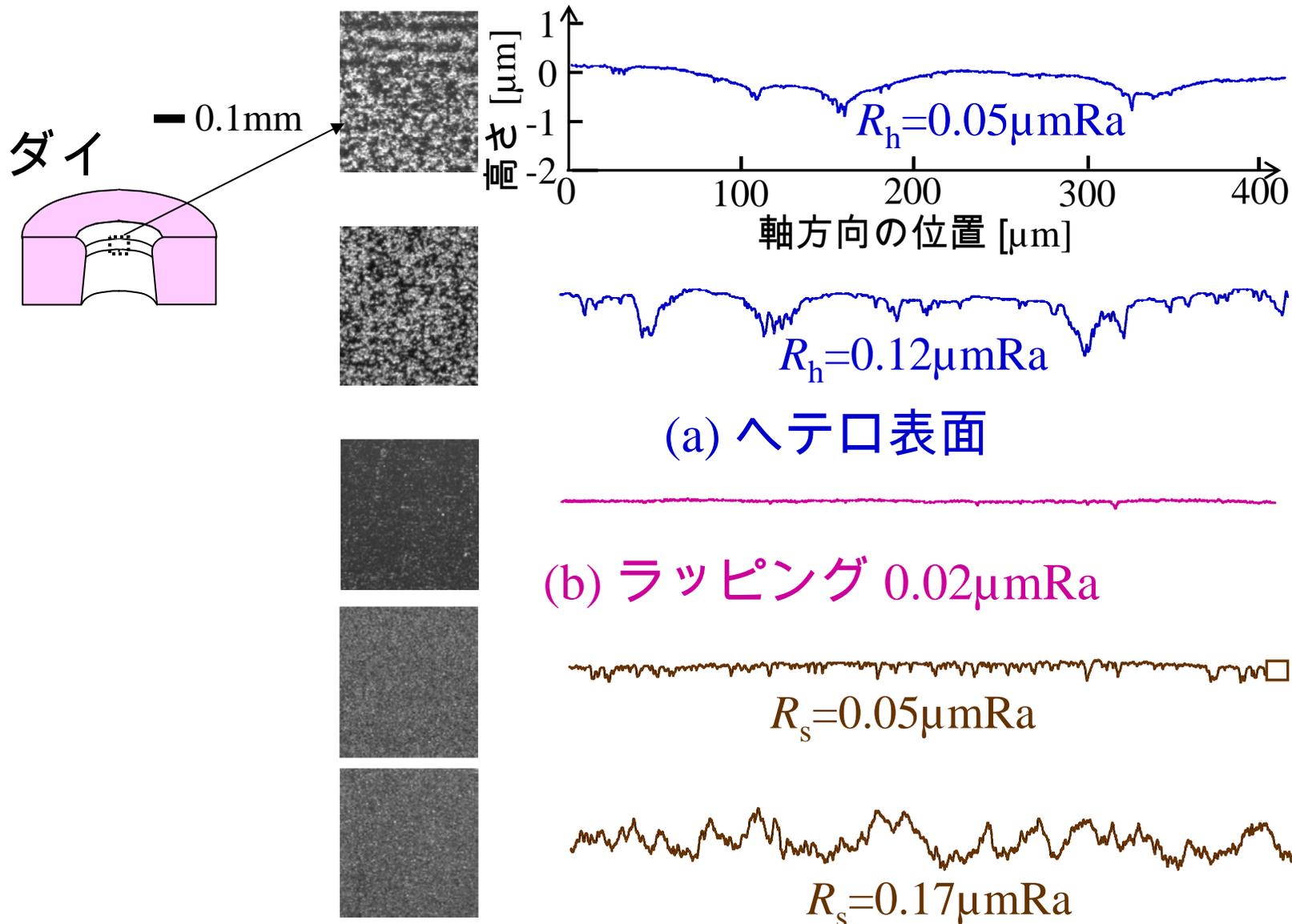
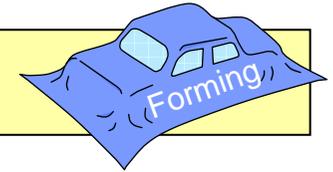
凹凸処理

研磨処理

観察部

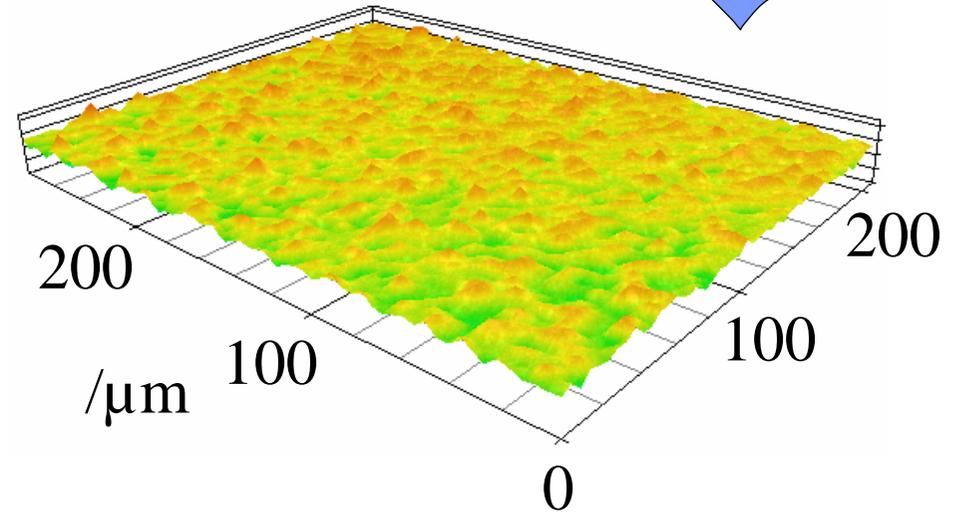
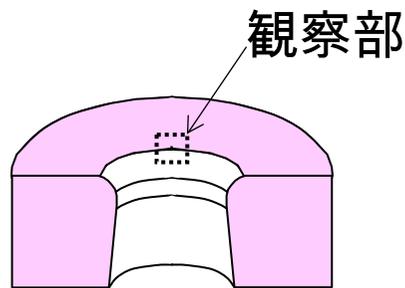
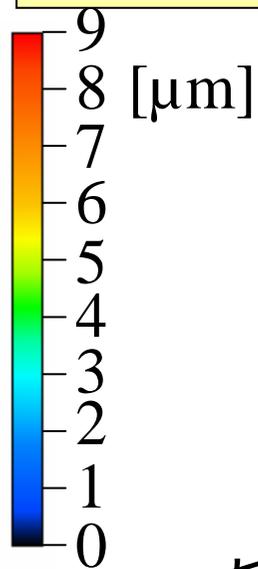
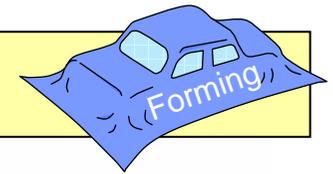


しごきダイランド部の軸方向表面性状

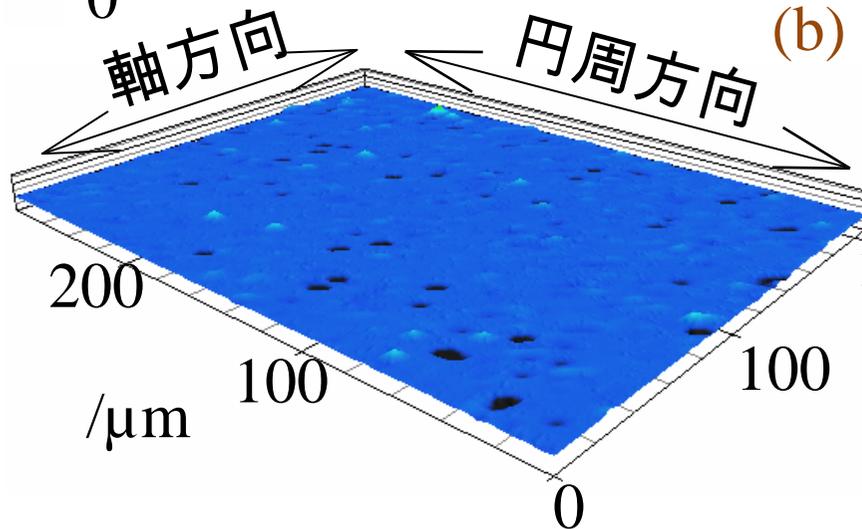


(c) ショットピーニングのみ

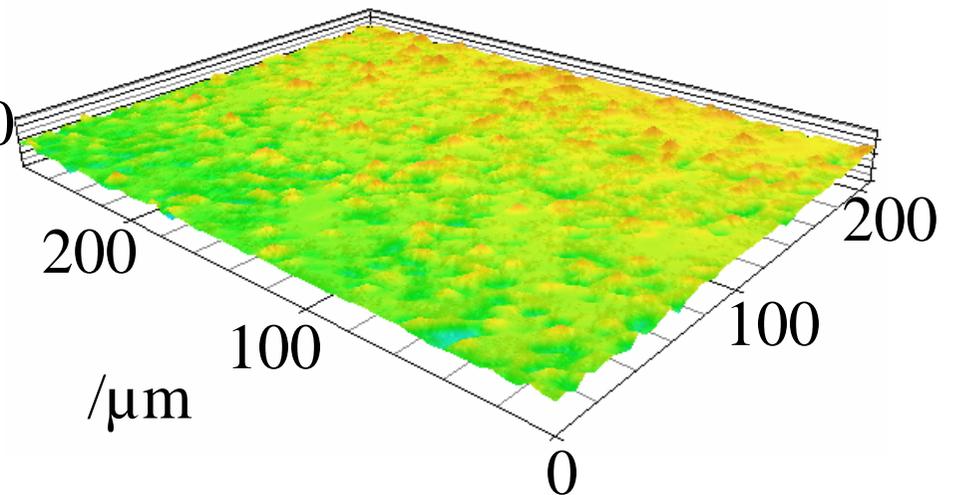
しごきダイランド部の3次元表面性状



(b) ショットピーニングのみ (0.17μmRa)

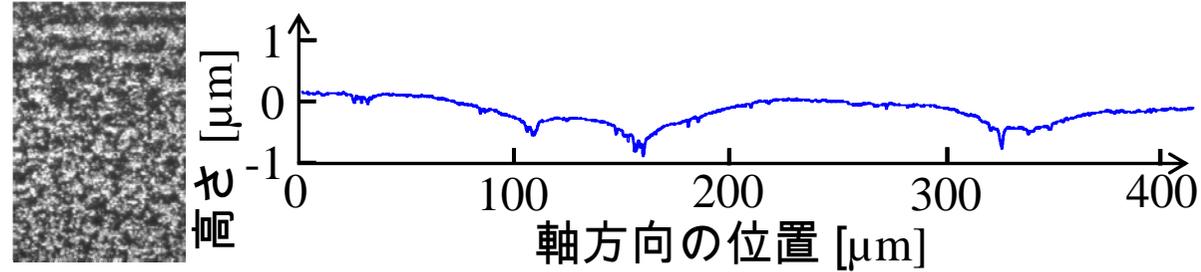
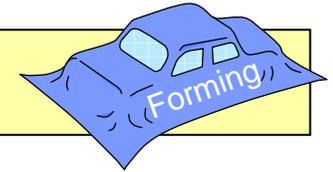


(a) ラッピング (0.02μmRa)



(c) ヘテロ表面 (0.06μmRa)

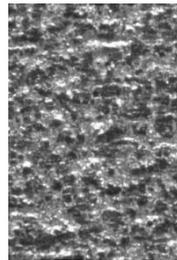
容器表面と表面粗さ



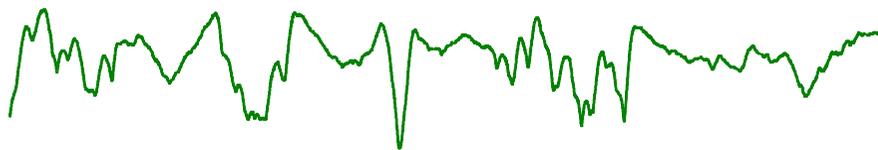
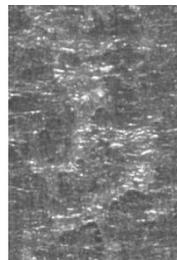
(a) ヘテロ表面, $R_h=0.05\mu\text{mRa}$



(b) SUS430容器, $0.27\mu\text{mRa}$



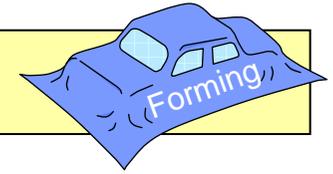
(c) SUS304容器, $0.30\mu\text{mRa}$



(d) A3003容器, $0.35\mu\text{mRa}$

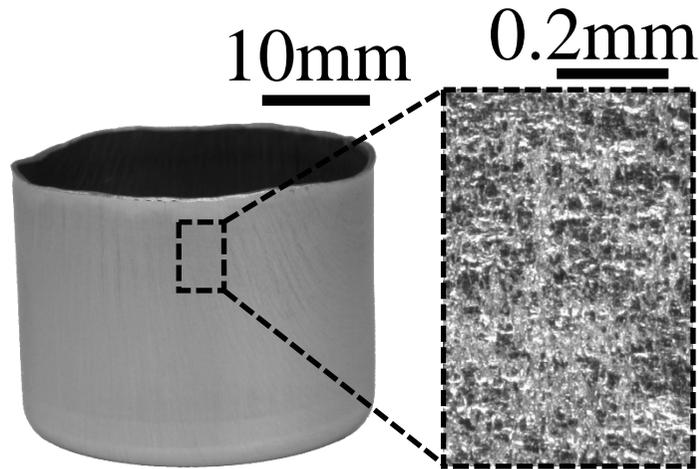
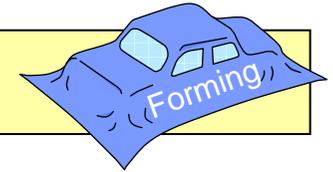
0.1mm

目次

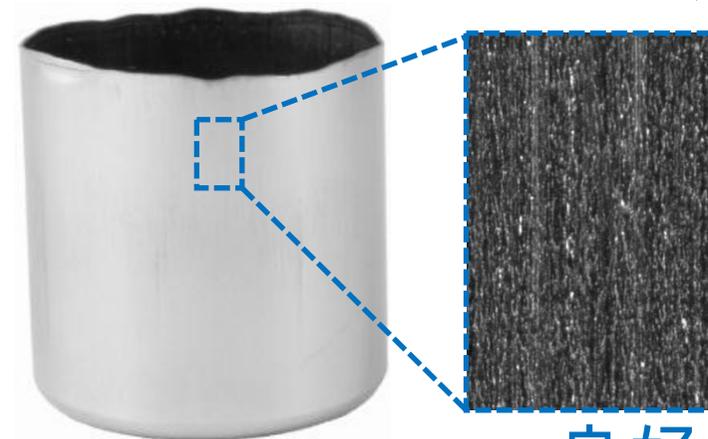


- ヘテロ表面サーメットダイとしごき加工条件
- ヘテロ表面ダイのしごき加工
- 潤滑メカニズム

SUS430におけるしごき加工後の容器

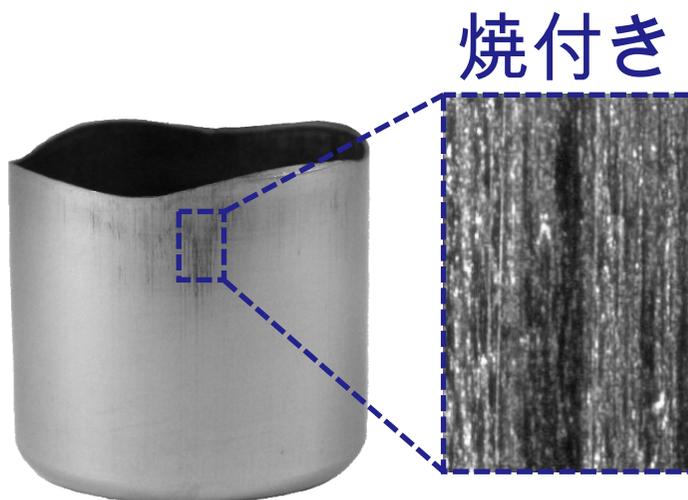


(a) 加工前



良好

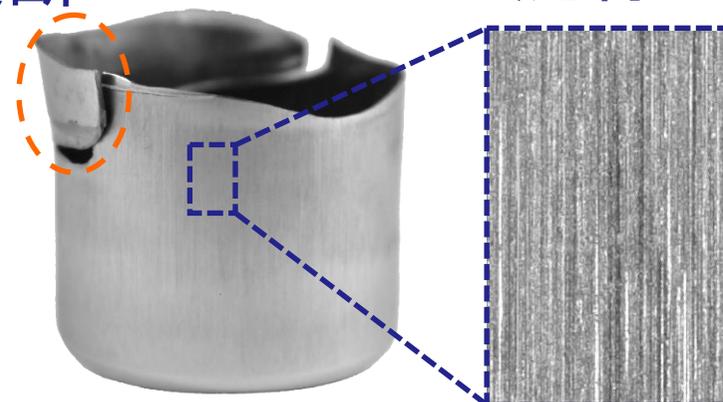
(b) ヘテロ ($0.12\mu\text{mRa}$),
 $r=26.7\%$



焼付き

(c) ラッピング,
 $r=17.7\%$

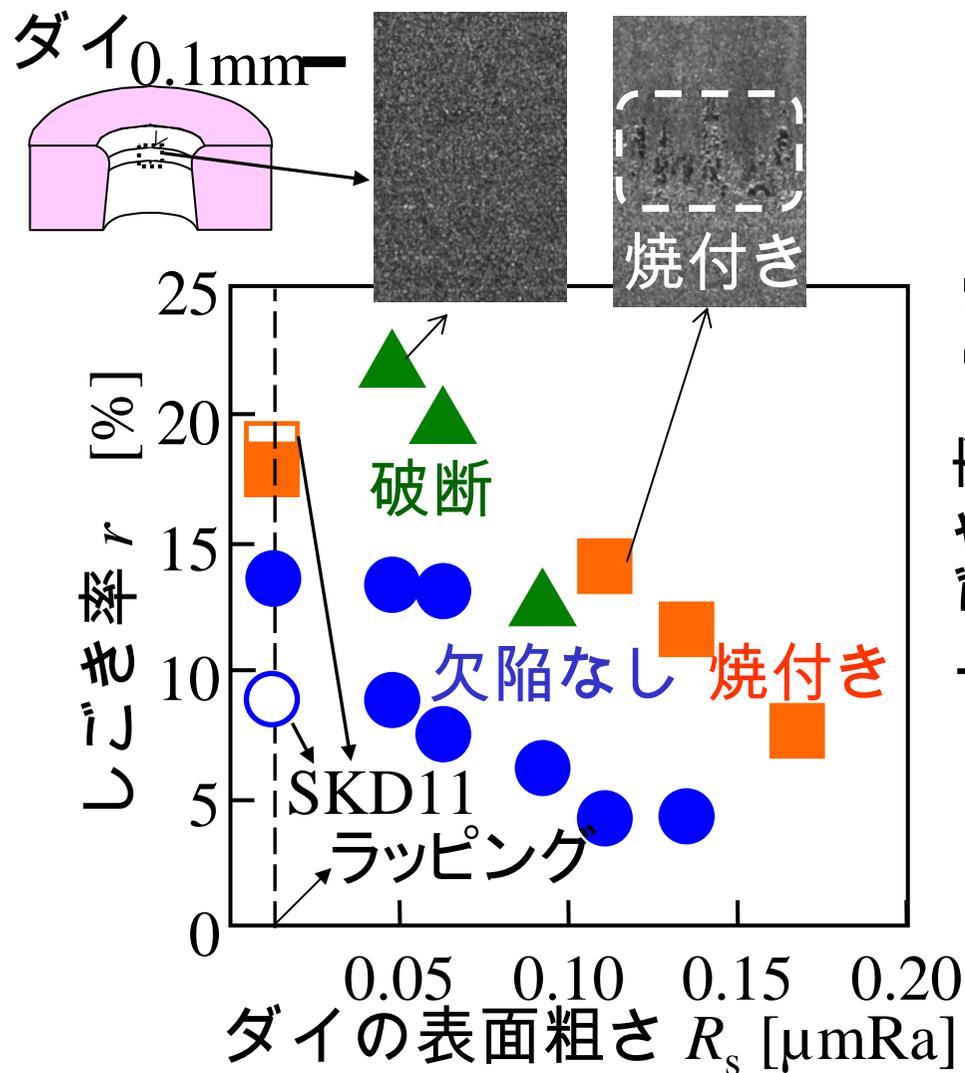
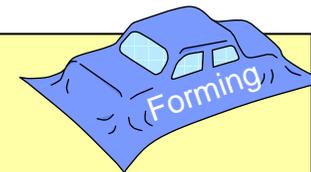
破断



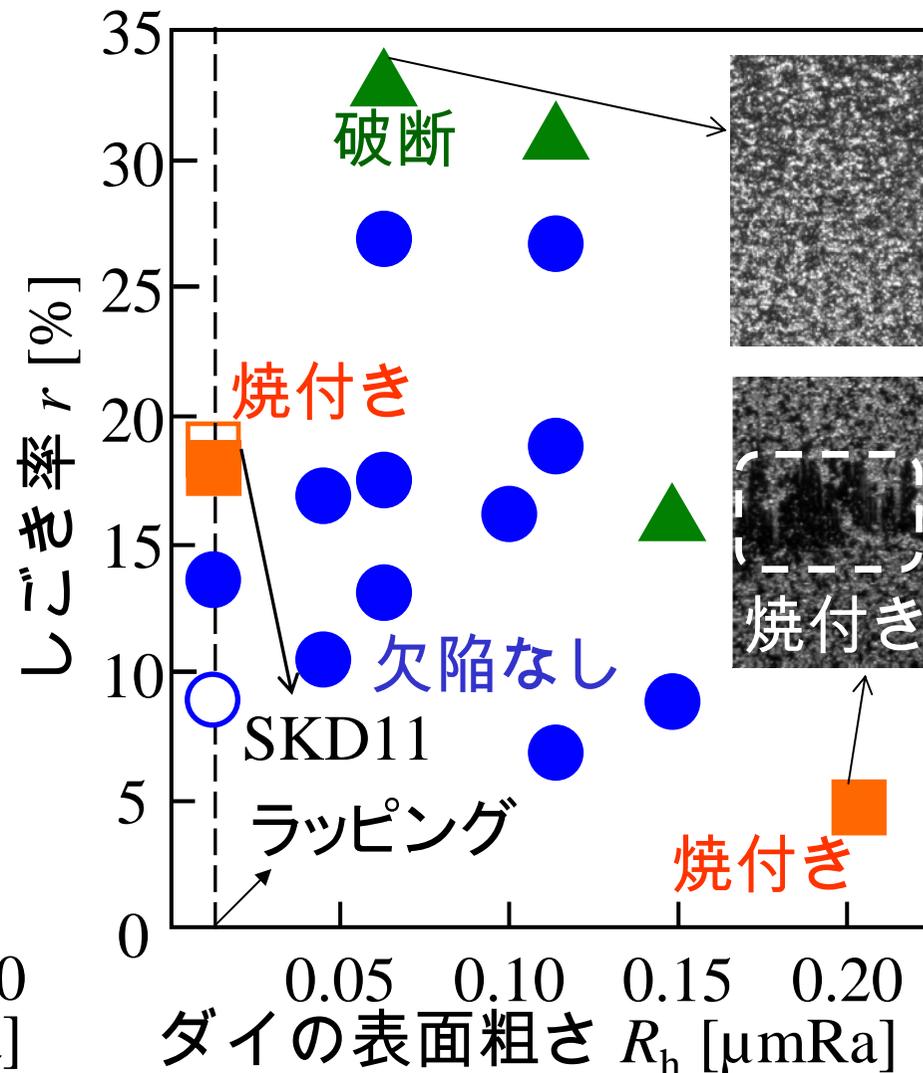
焼付き

(d) ショットピーニングのみ
($0.37\mu\text{mRa}$), $r=7.4\%$

成形限界に及ぼすダイランド部の影響 (塩素系低粘度潤滑剤, $v=100\text{mm/s}$)

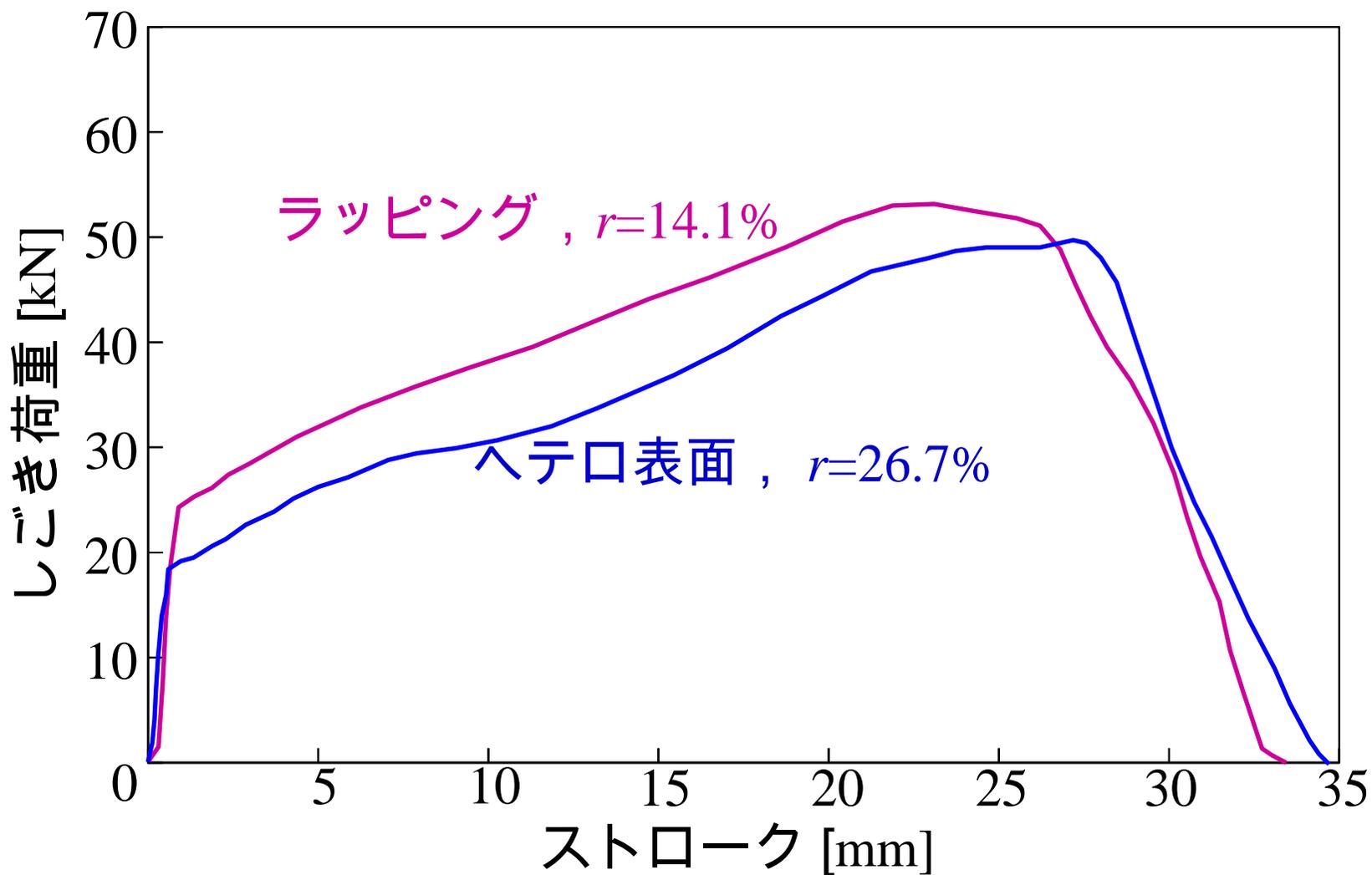
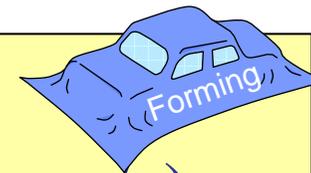


(a) ショットピーニングのみ

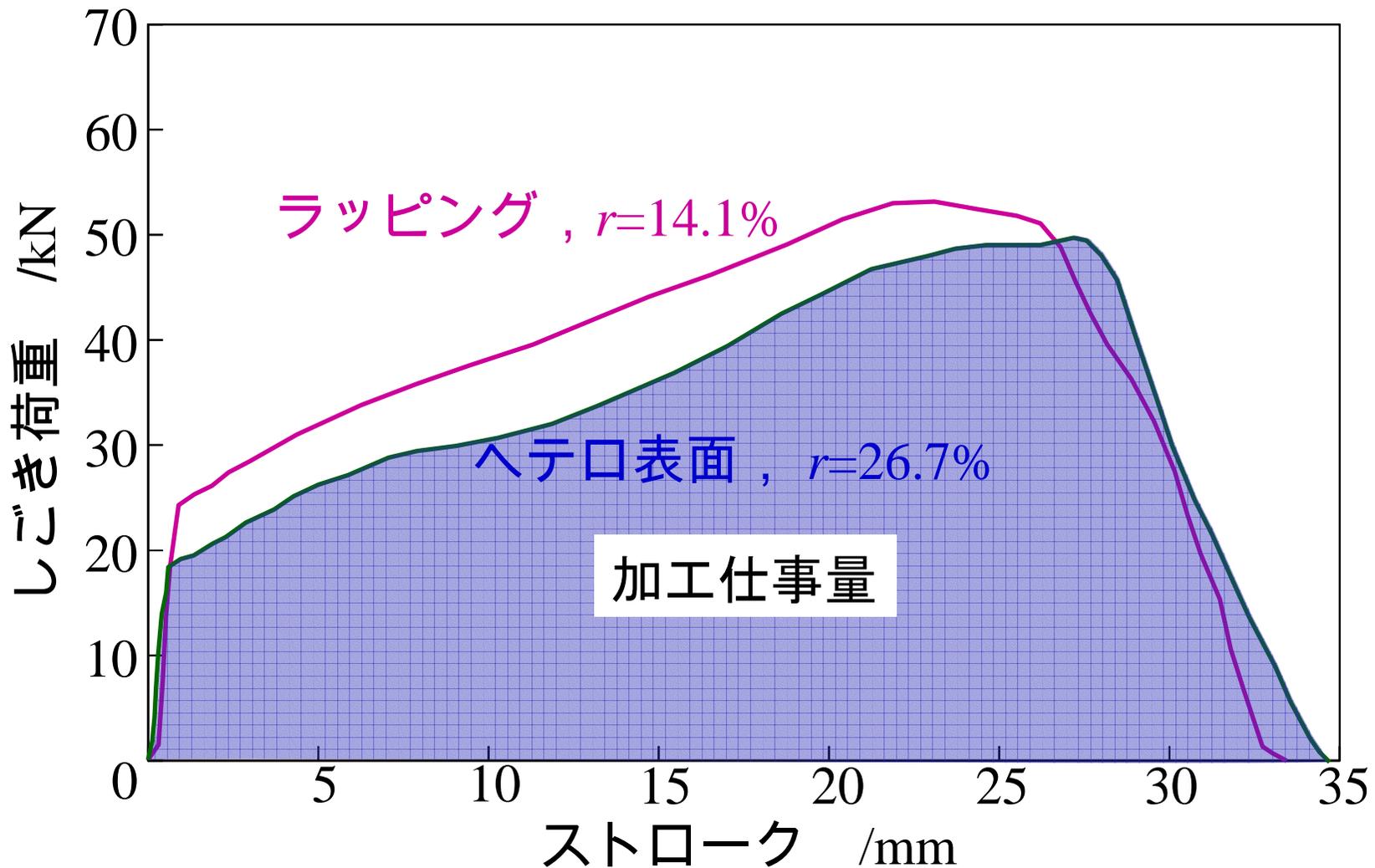
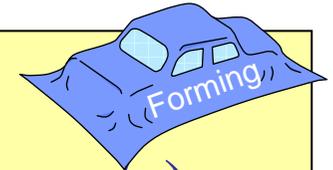


(b) ヘテロ表面

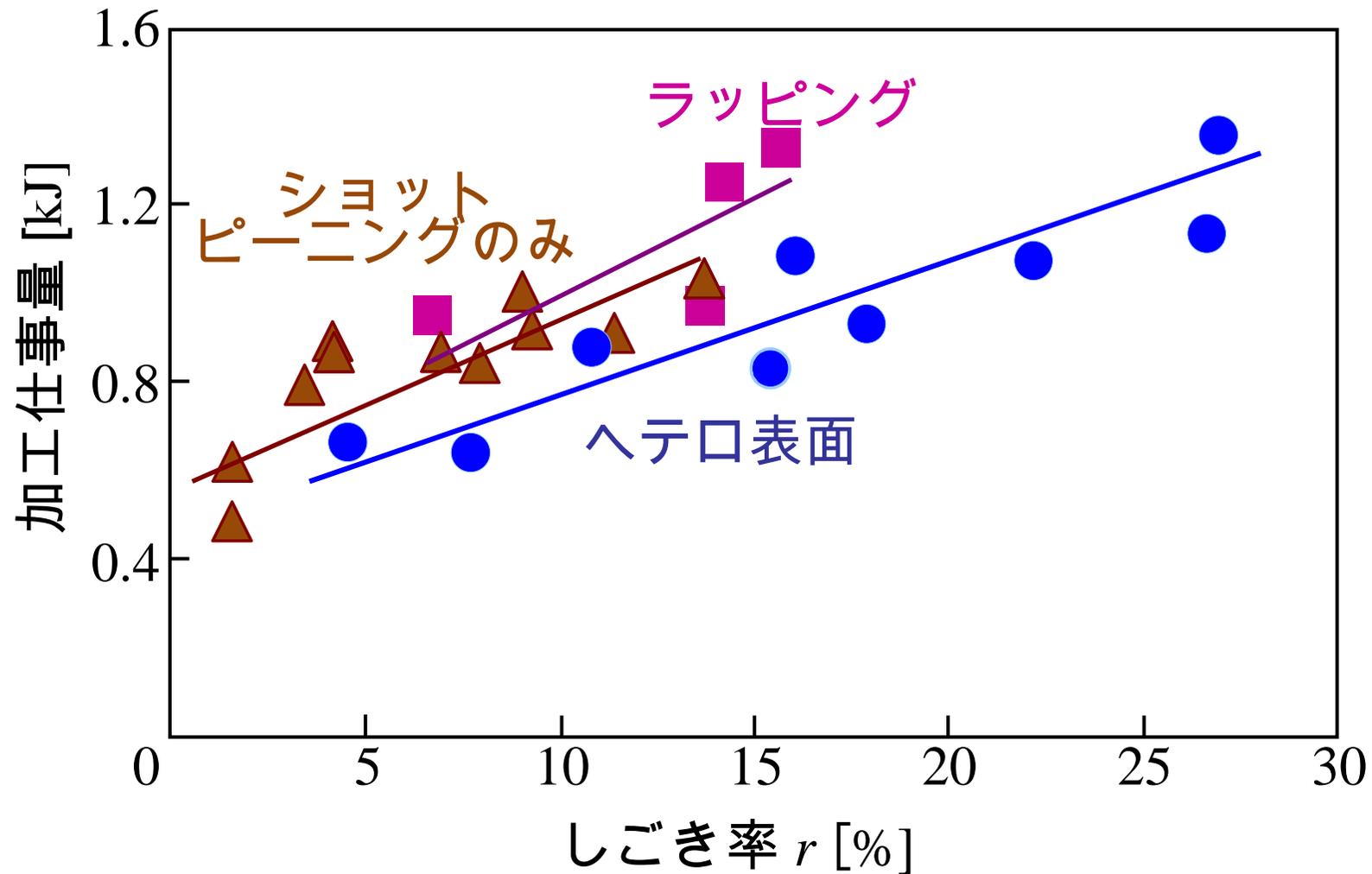
焼付き限界付近におけるしごき荷重-ストローク線図(塩素系低粘度潤滑剤, $v=100\text{mm/s}$)



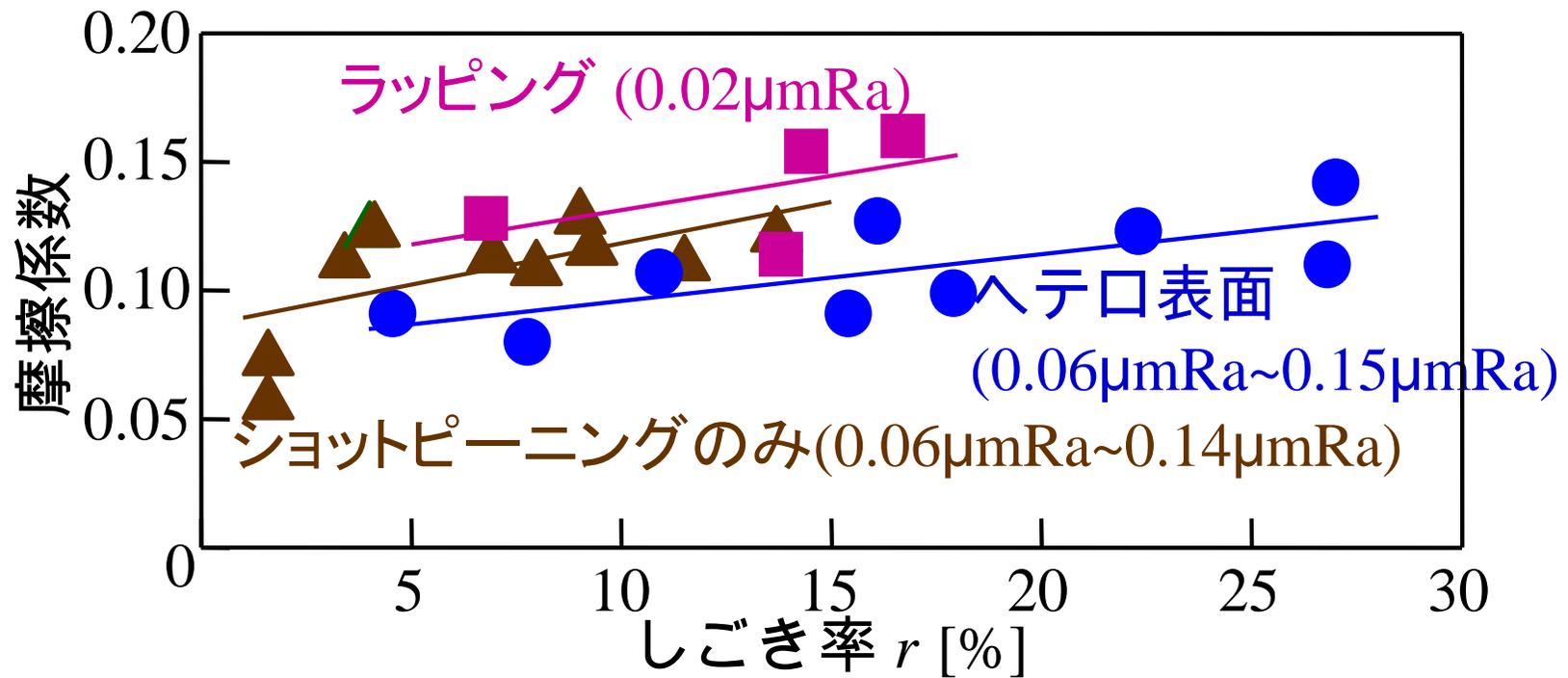
焼付き限界付近におけるしごき荷重-ストローク線図(塩素系低粘度潤滑剤, $v=100\text{mm/s}$)



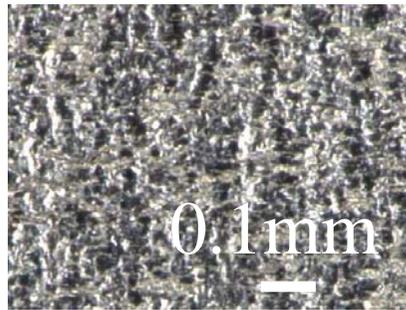
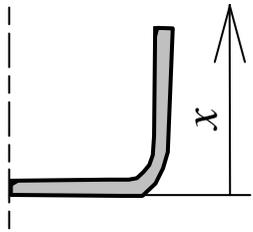
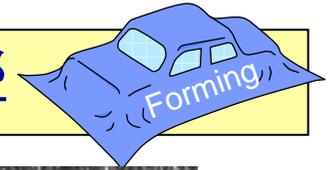
加工仕事量に及ぼすヘテロダイ表面の影響



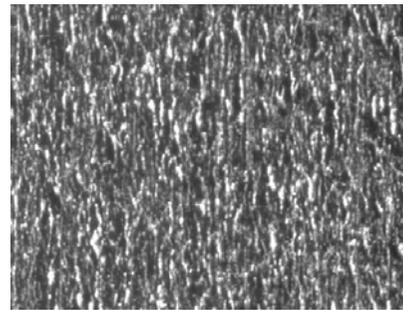
摩擦係数に及ぼすヘテロ表面ダイの影響



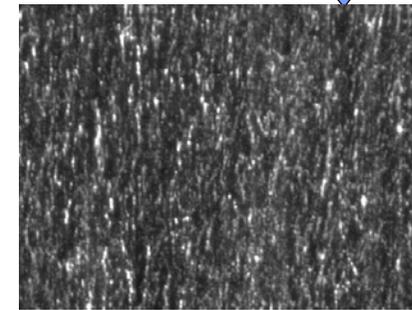
容器表面粗さに及ぼすヘテロ表面の影響



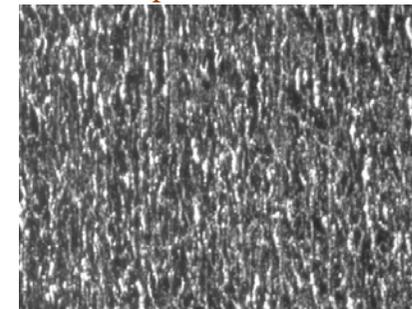
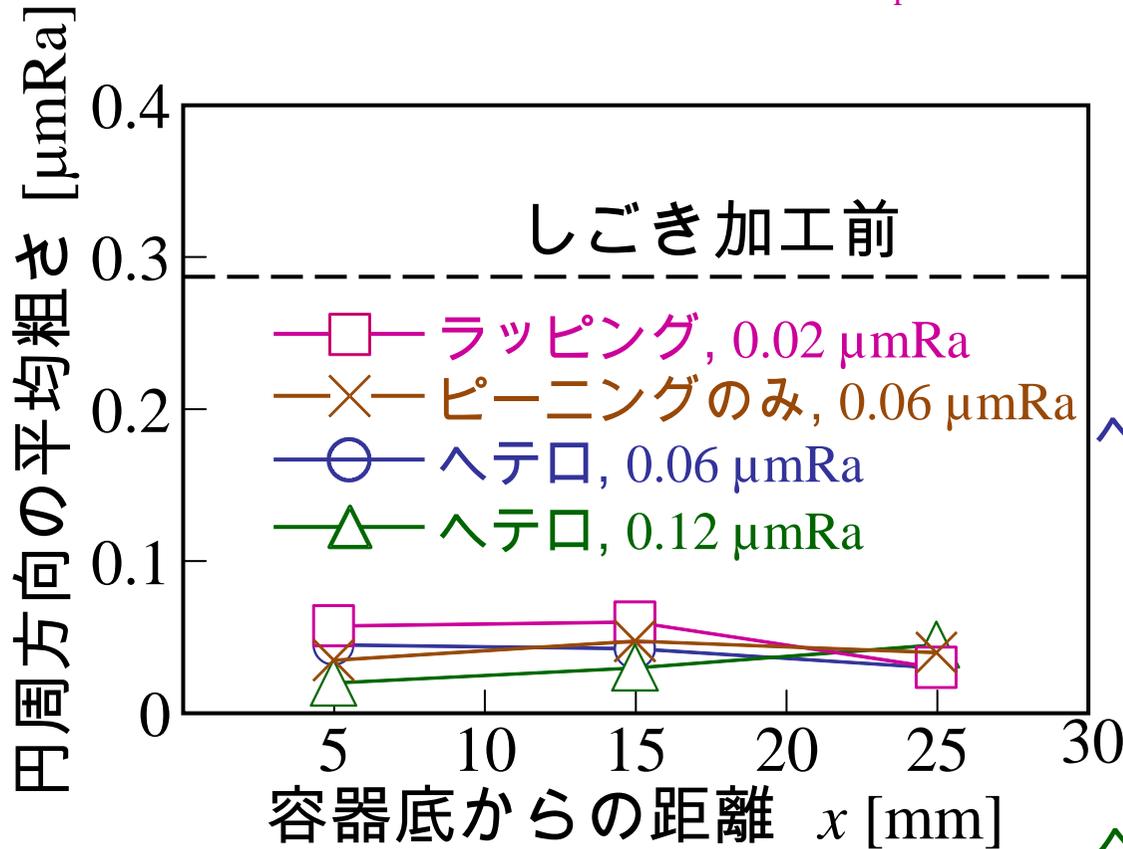
しごき加工前



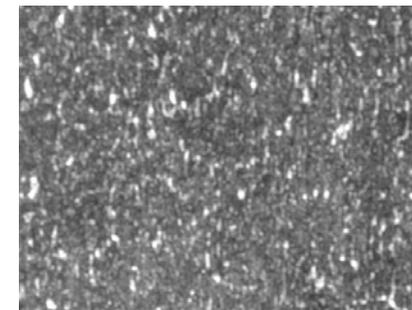
ラッピング, $r_r=13.76\%$



ピーニングのみ ($0.06\mu\text{mRa}$),
 $r_r=13.74\%$



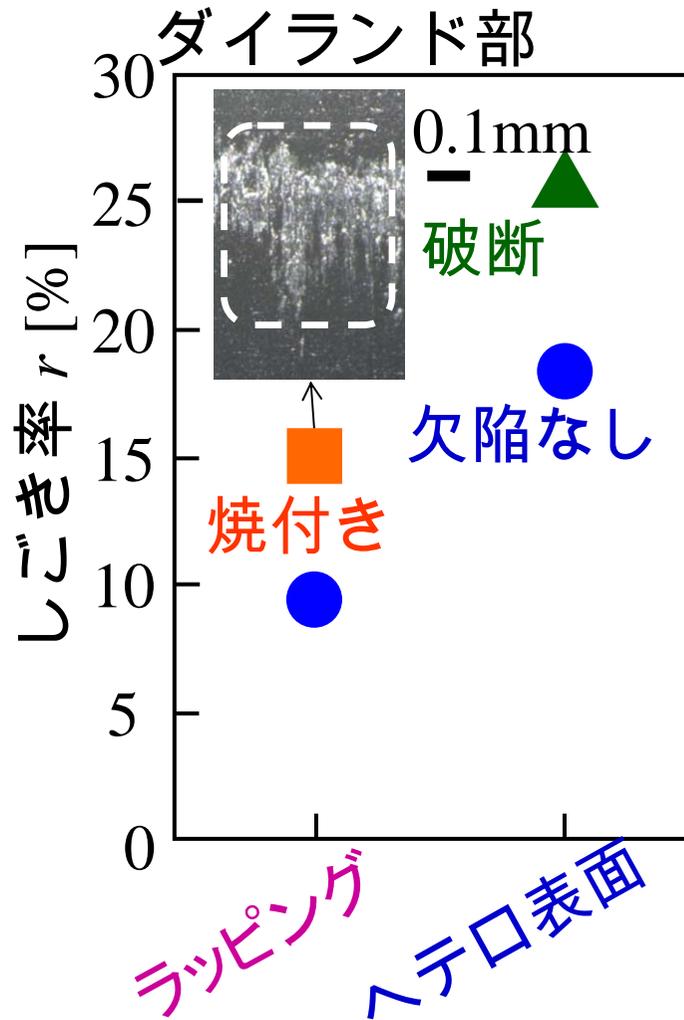
ヘテロ ($0.06\mu\text{mRa}$), $r_r=17.09\%$



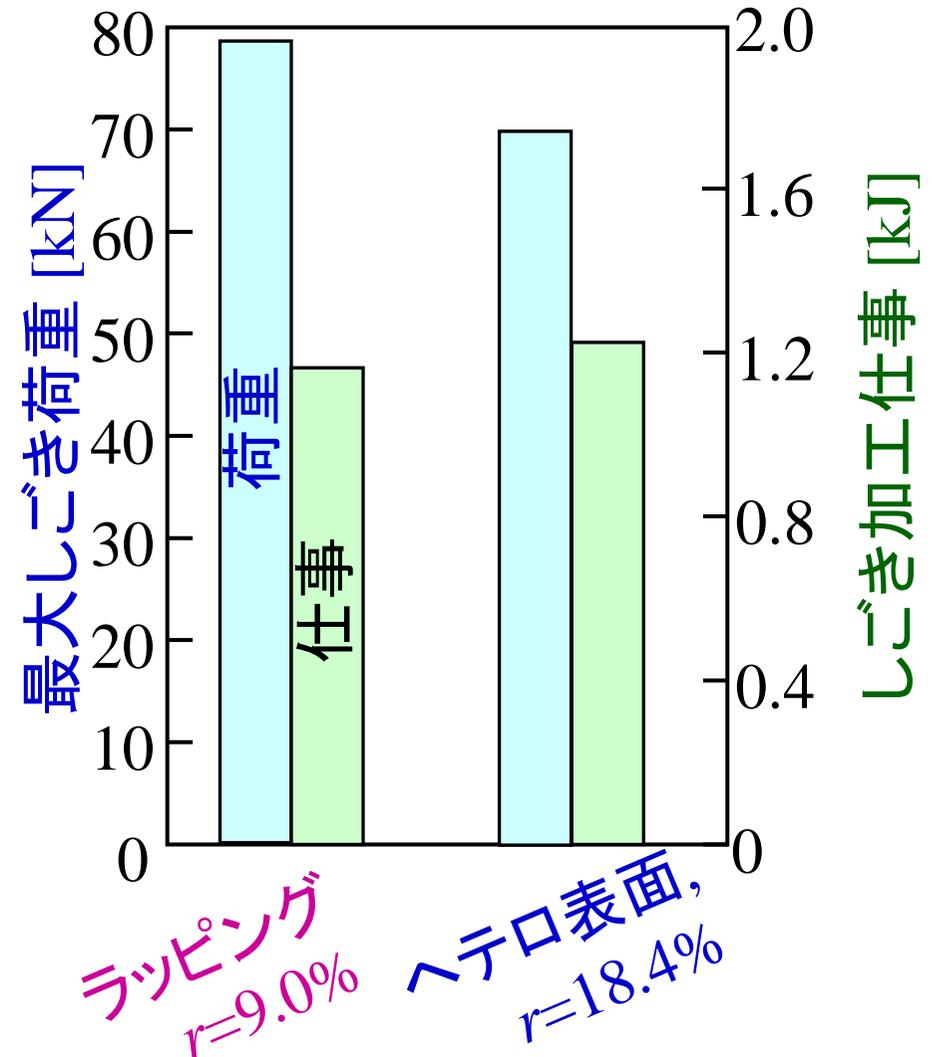
ヘテロ ($0.12\mu\text{mRa}$), $r_r=15.43\%$

SUS304の成形限界に及ぼすヘテロ表面の影響

(塩素系低粘度潤滑剤, $v=100\text{mm/s}$, $R_h=0.06\mu\text{mRa}$)

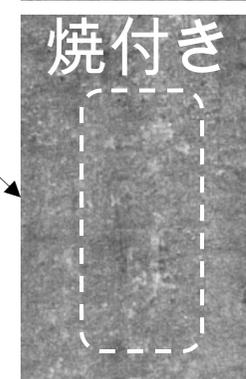
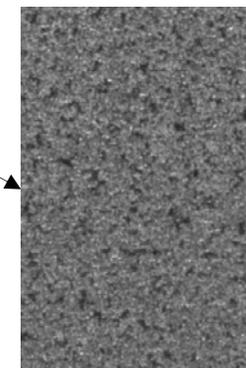
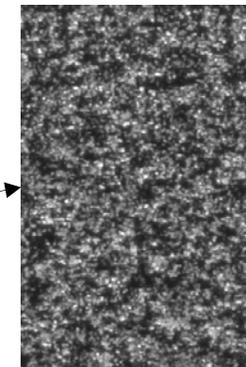
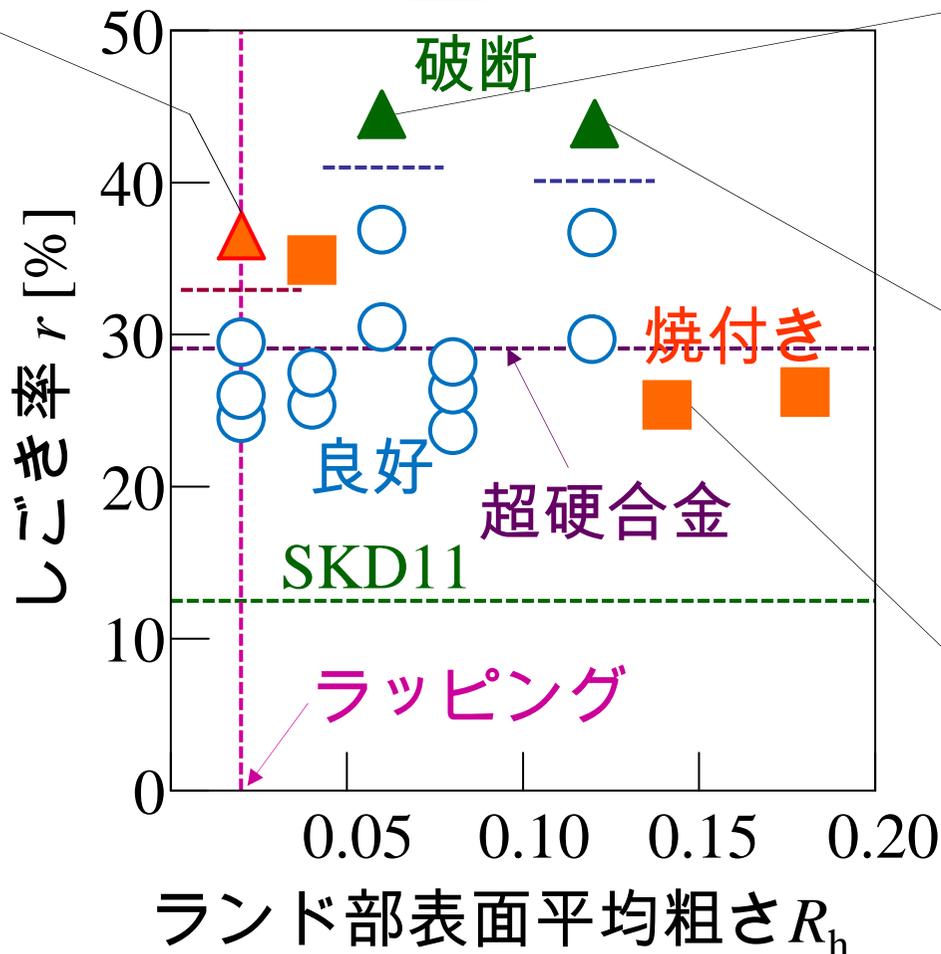
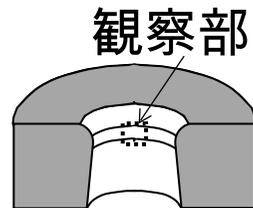
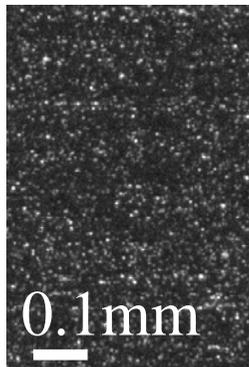


(a) しごき加工限界

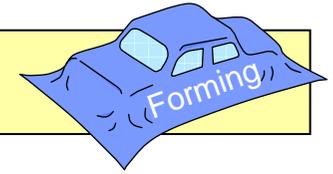


(b) 最大荷重と仕事

A3003の成形限界に及ぼすヘテロ表面の影響 (塩素系低粘度潤滑剤, $v=100\text{mm/s}$, $R_h=0.06\mu\text{mRa}$)

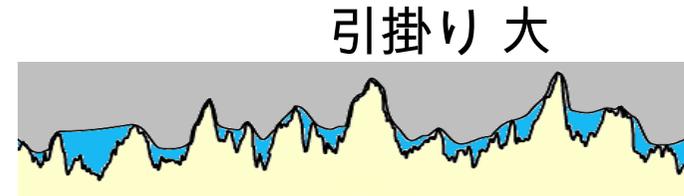
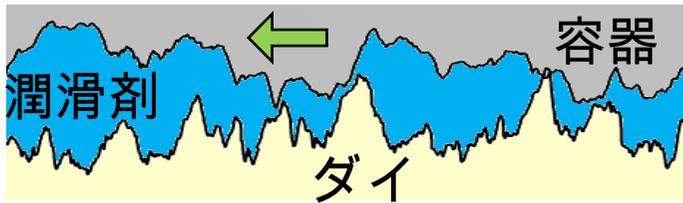
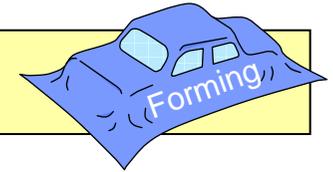


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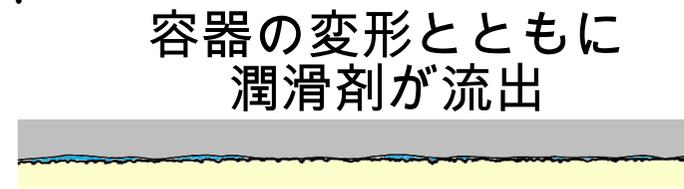
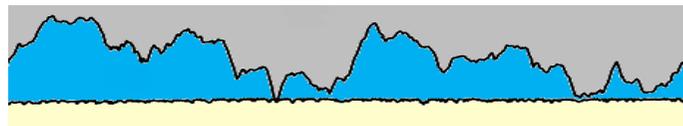


- ヘテロ表面サーメットダイとしごき加工条件
- ヘテロ表面ダイのしごき加工
- 潤滑メカニズム

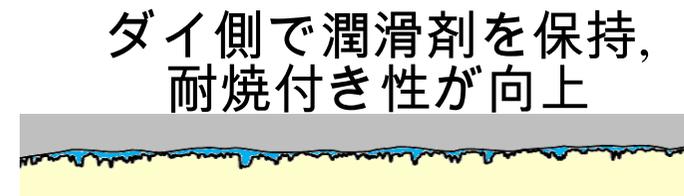
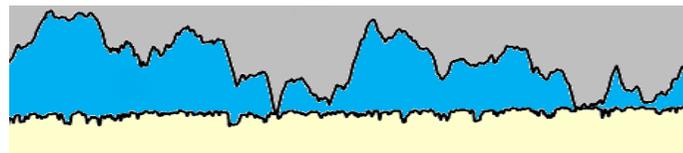
ダイ表面と容器間の潤滑メカニズム



(a) 切削後, $0.45\mu\text{mRa}$



(b) ラッピング, $0.02\mu\text{mRa}$

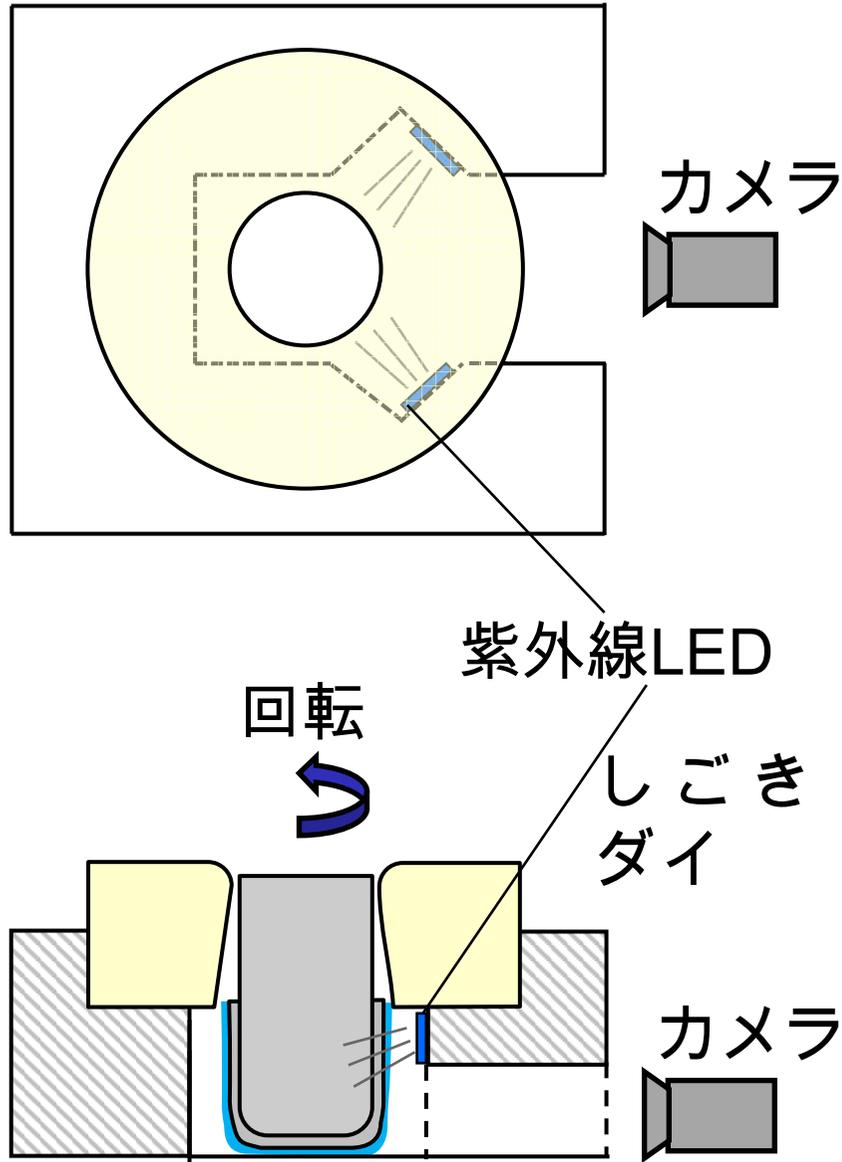
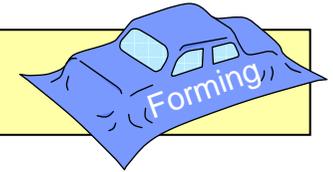


(c) ショットピーニングのみ, $0.06\mu\text{mRa}$

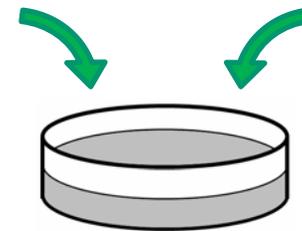
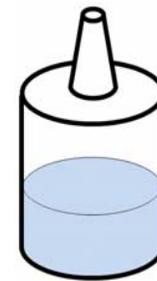


(d) ヘテロ表面, $0.06\mu\text{mRa}$

紫外線光による残留潤滑剤観察方法



極圧添加剤あり塩素系低粘度潤滑剤
(動粘度: $2.9\text{mm}^2/\text{s}$)



蛍光塗料



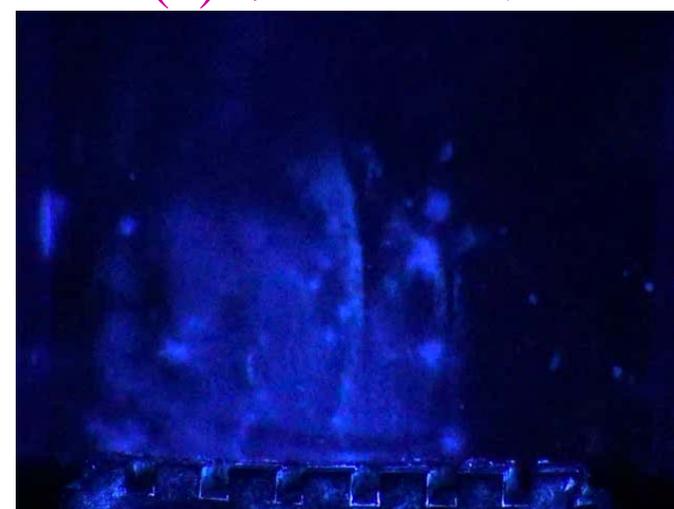
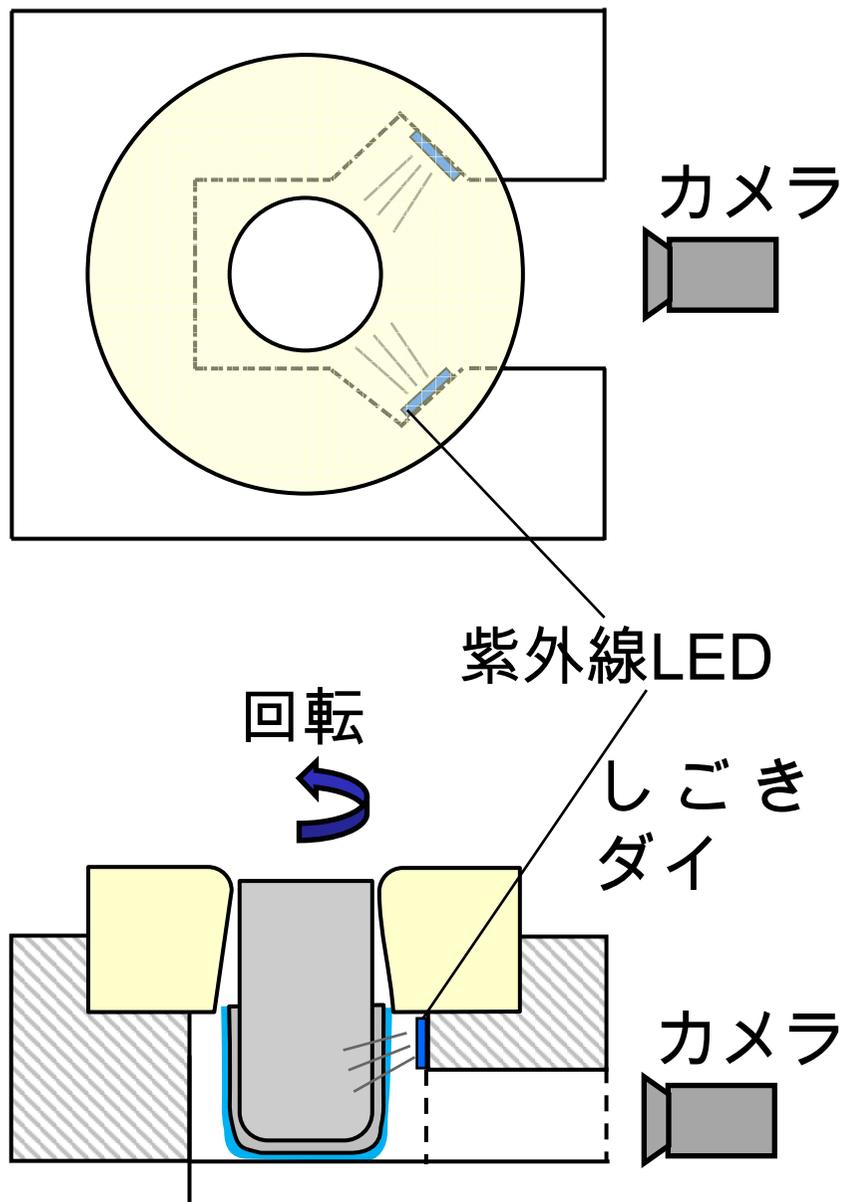
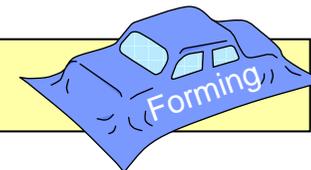
1wt%で混合

青白く発光

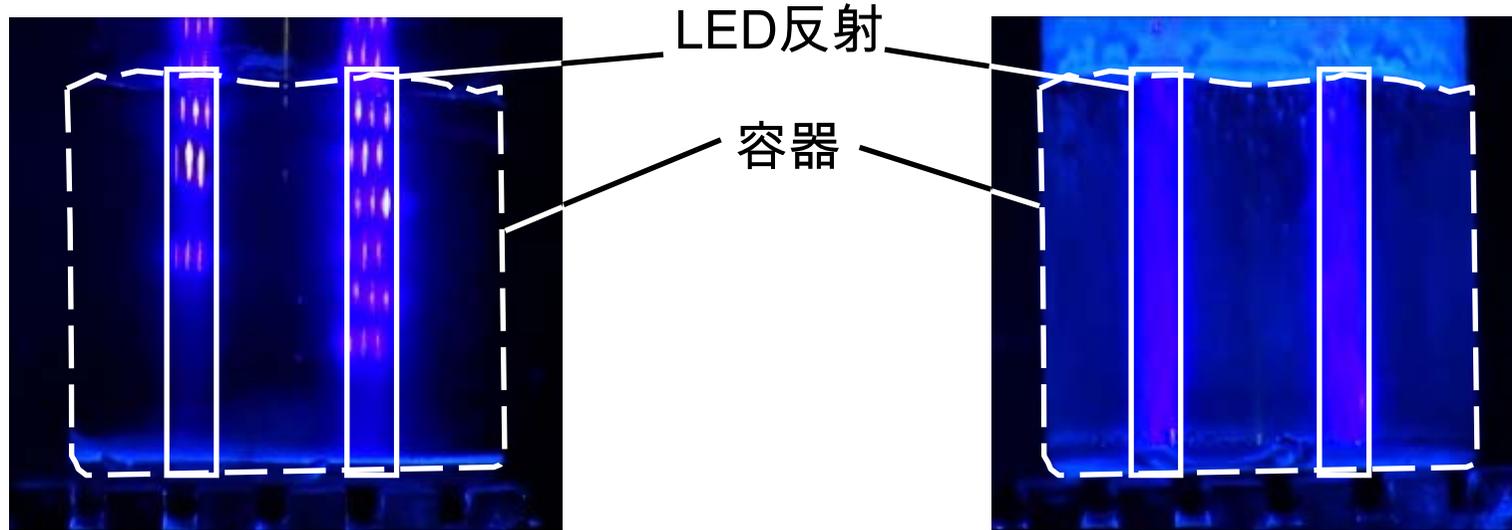
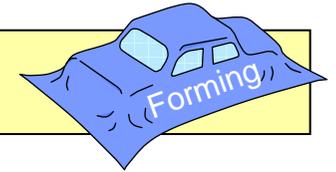


紫外線光

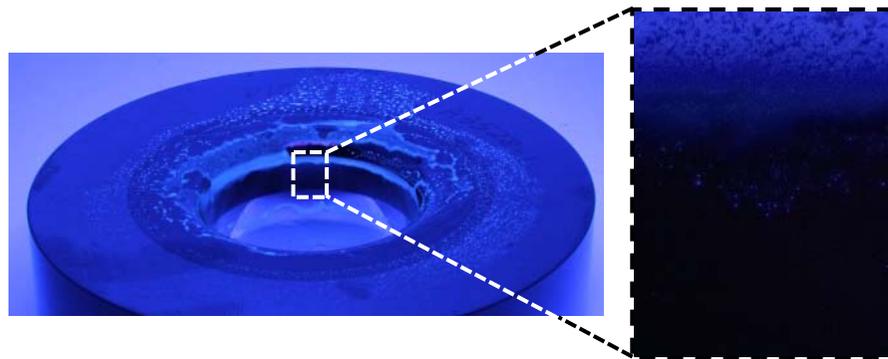
加工後容器表面の残留潤滑剤($v=100\text{mm/s}$)



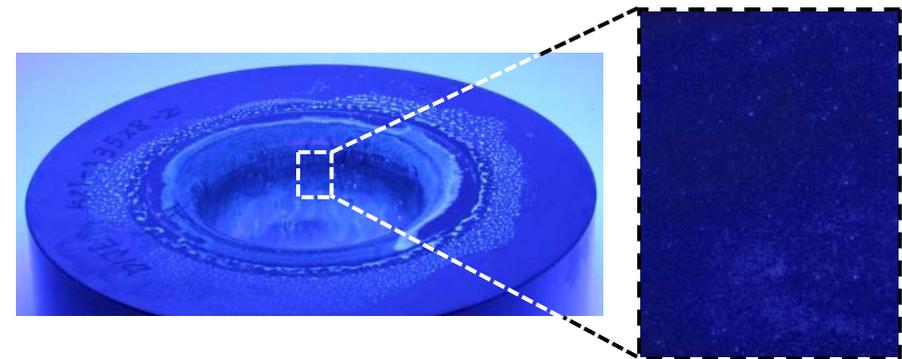
しごき加工後の残留潤滑剤



加工後容器



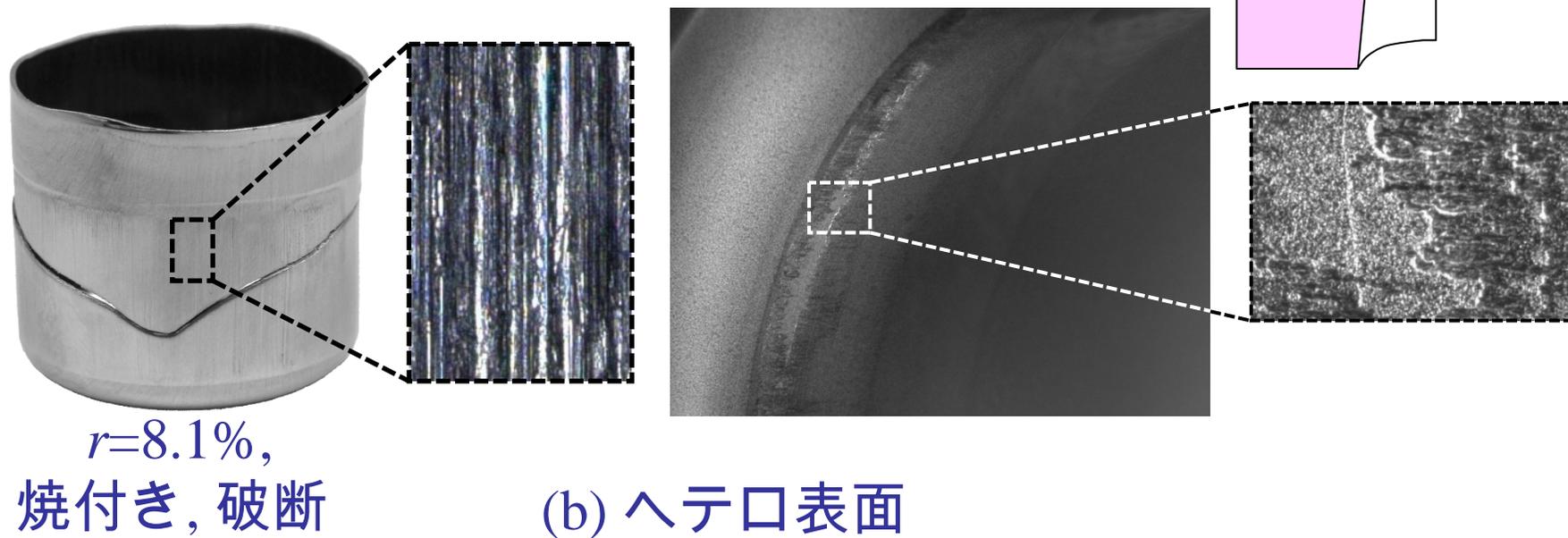
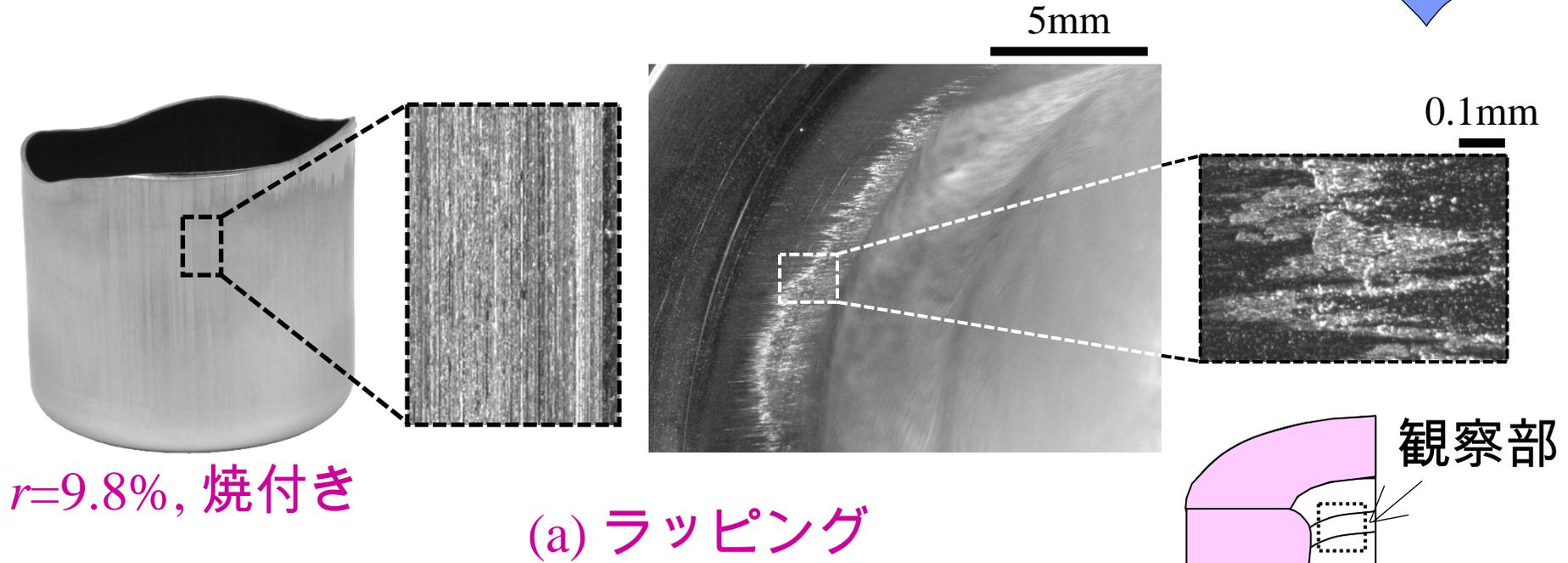
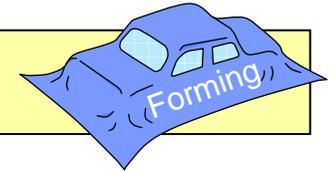
残留潤滑剤量 少
(a) ラッピング



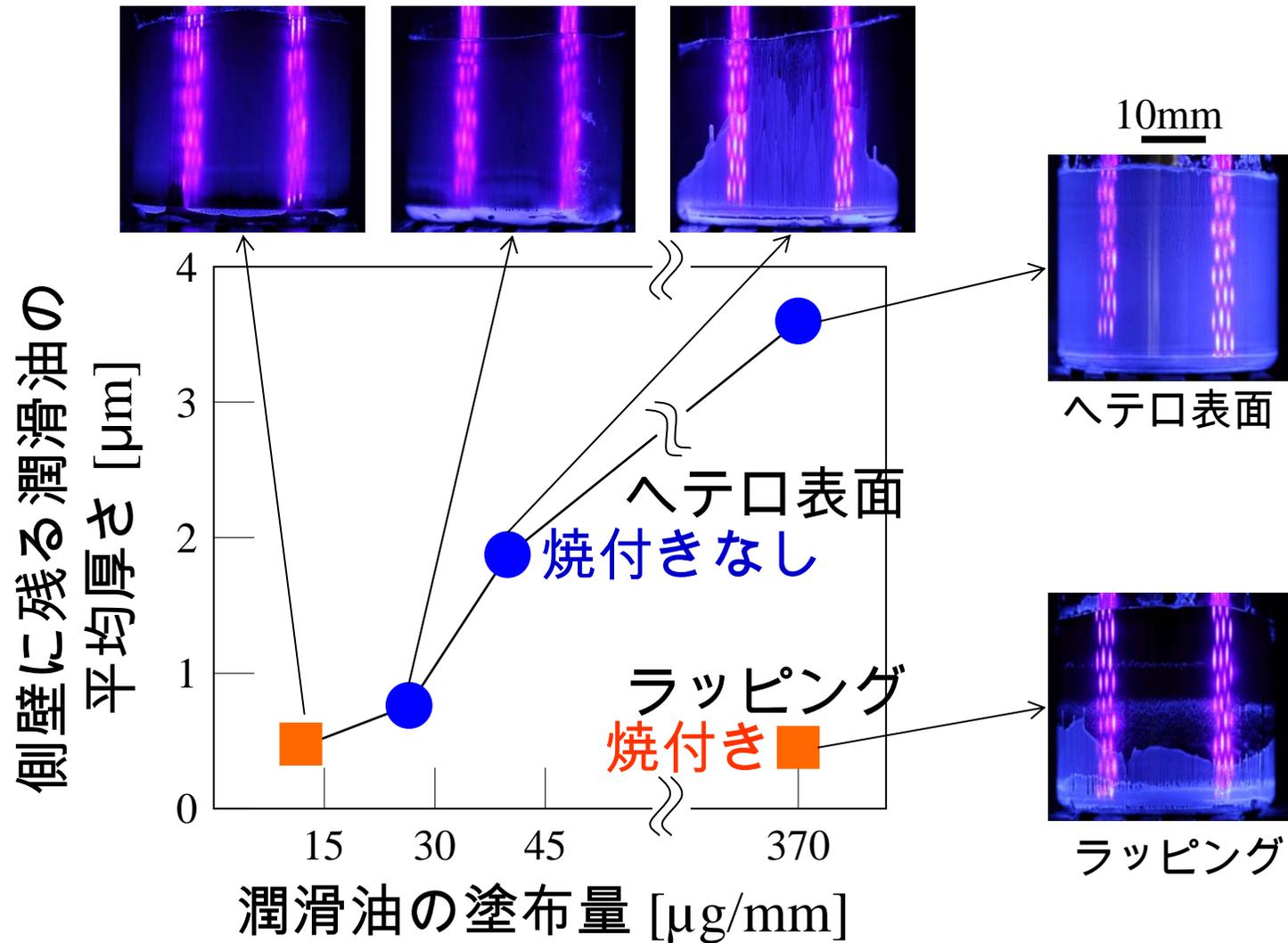
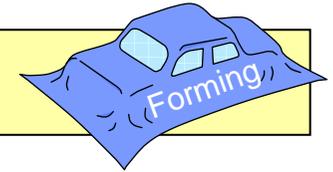
残留潤滑剤量 多
(b) ヘテロ表面

加工後ダイ

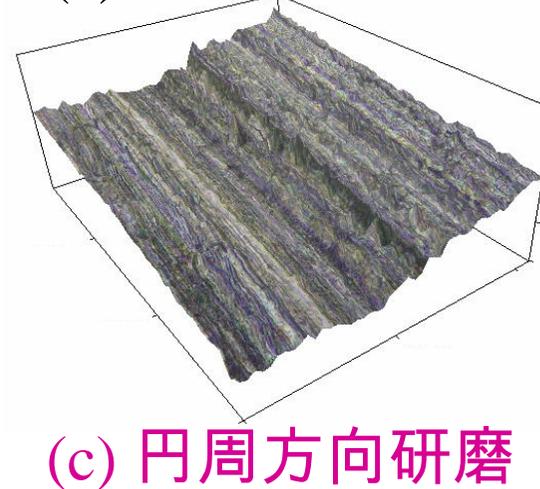
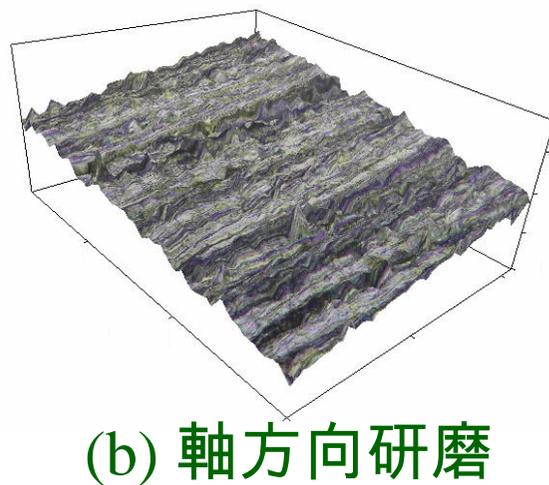
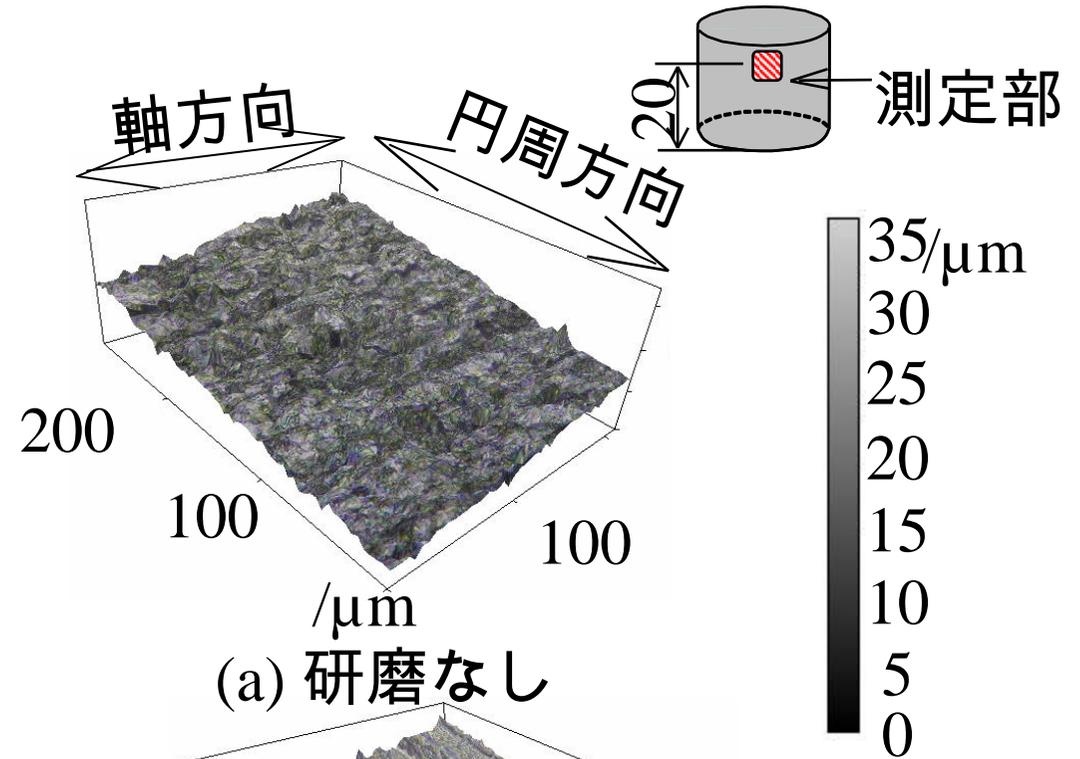
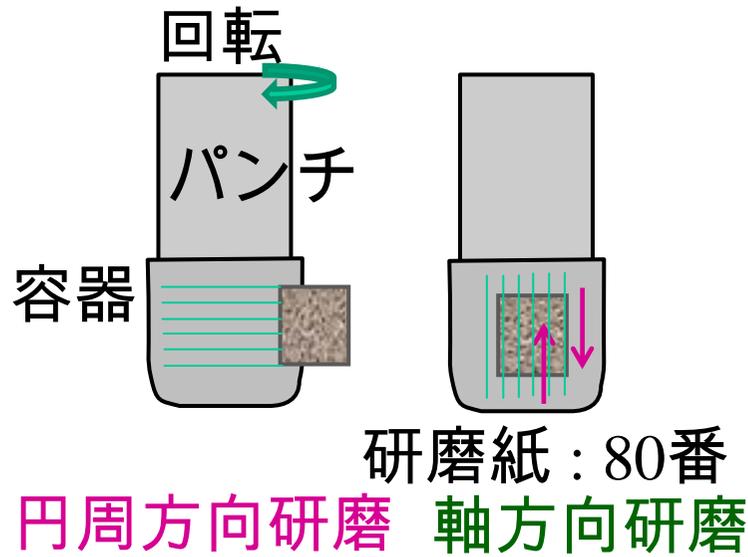
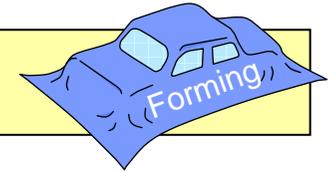
無潤滑状態でのしごき加工実験



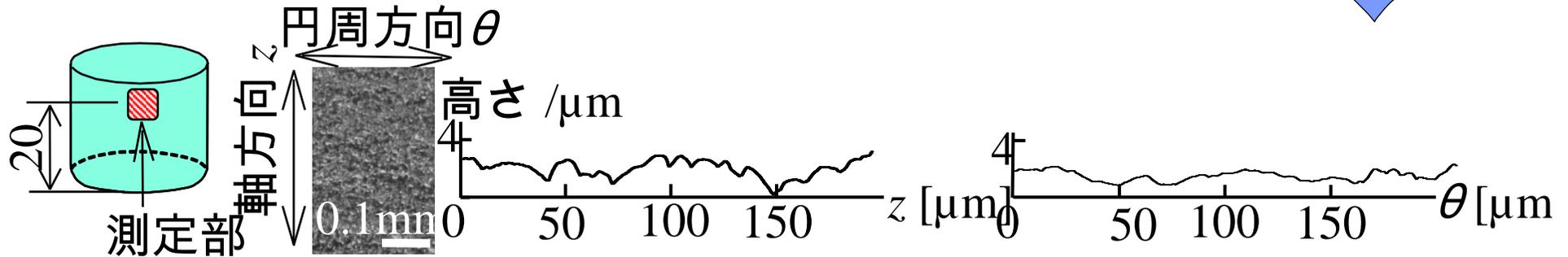
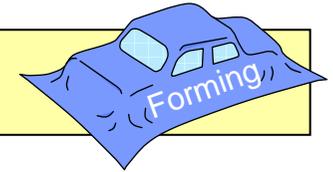
ヘテロ表面ダイスにおける潤滑油の量



研磨により粗さを变化させた容器



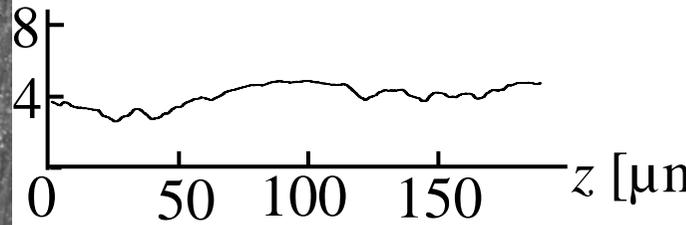
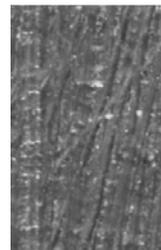
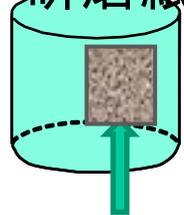
研磨された容器の表面性状



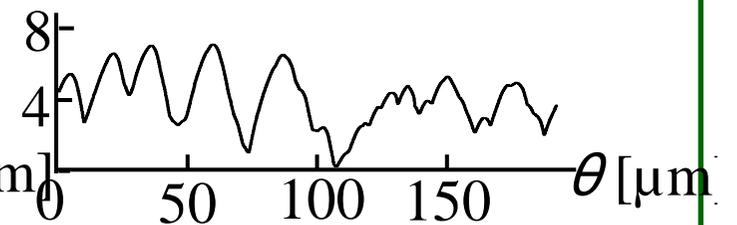
(a) 研磨なし $R_z=0.30\mu\text{mRa}$

$R_\theta=0.27\mu\text{mRa}$

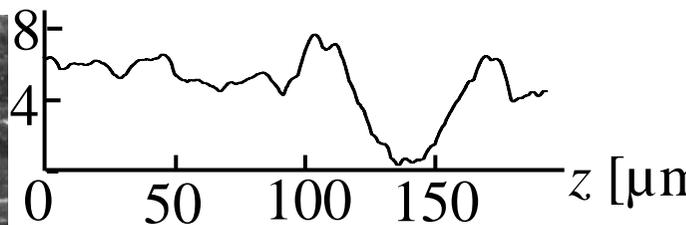
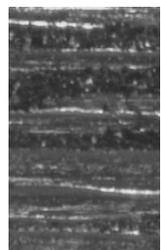
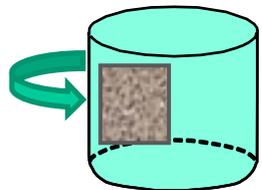
研磨紙



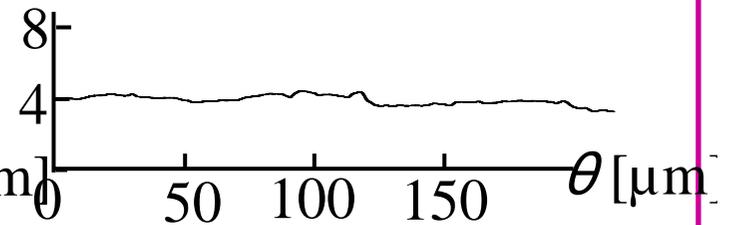
(b) 軸方向研磨 $R_z=0.35\mu\text{mRa}$



$R_\theta=0.60\mu\text{mRa}$

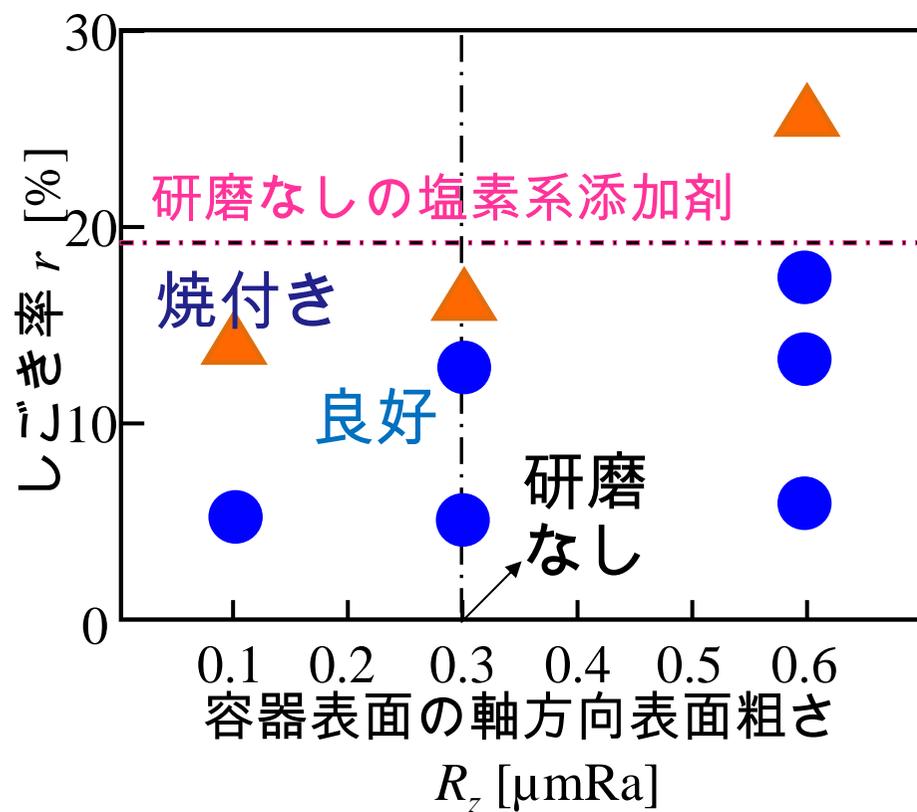
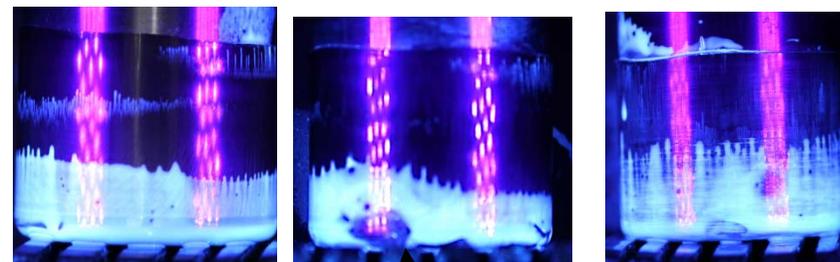
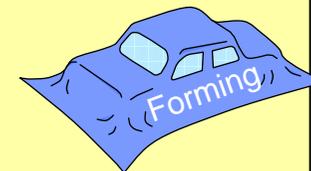


(c) 円周方向研磨 $R_z=0.60\mu\text{mRa}$

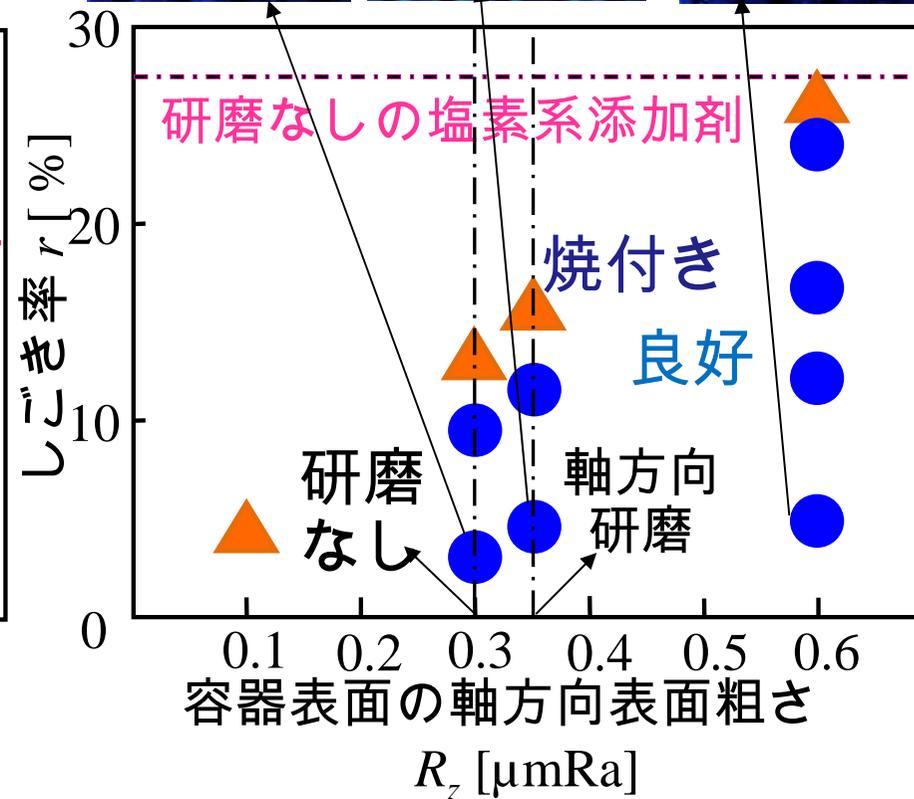


$R_\theta=0.11\mu\text{mRa}$

成形限界に及ぼす容器表面粗さの影響 (硫黄系潤滑剤96mm²/s)

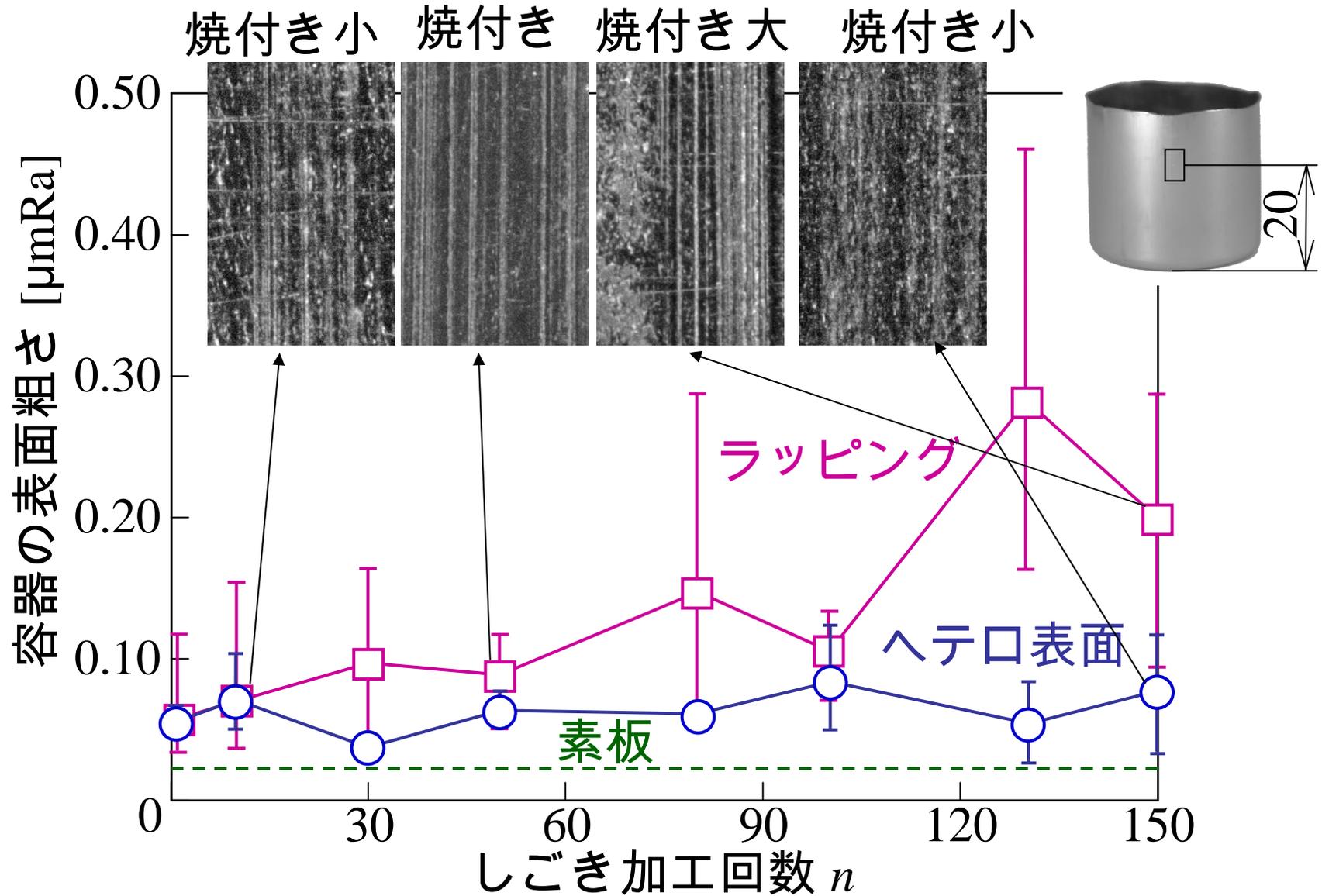
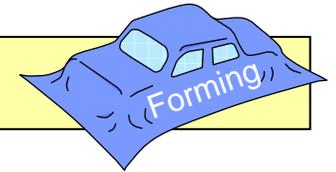


(a) ラッピング

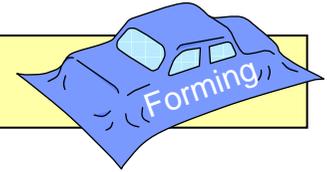


(b) ヘテロ表面

容器表面粗さに及ぼす加工回数の影響($r=9\%$)

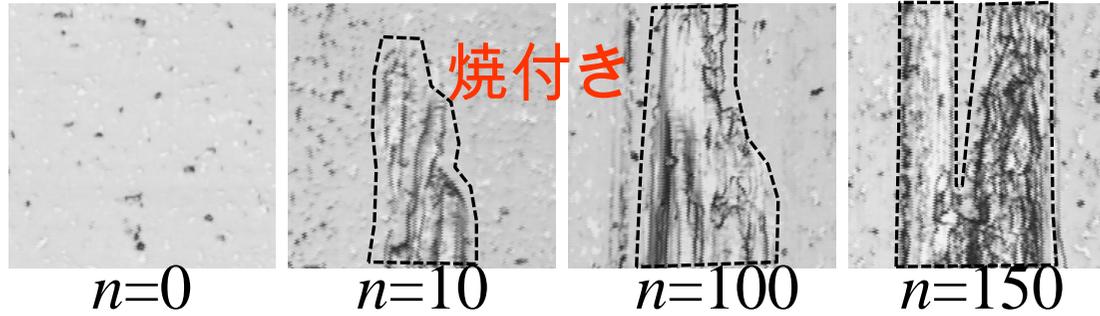


容器表面粗さに及ぼす加工回数の影響($r=9\%$)

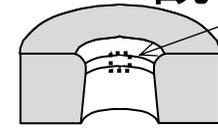


ラッピング

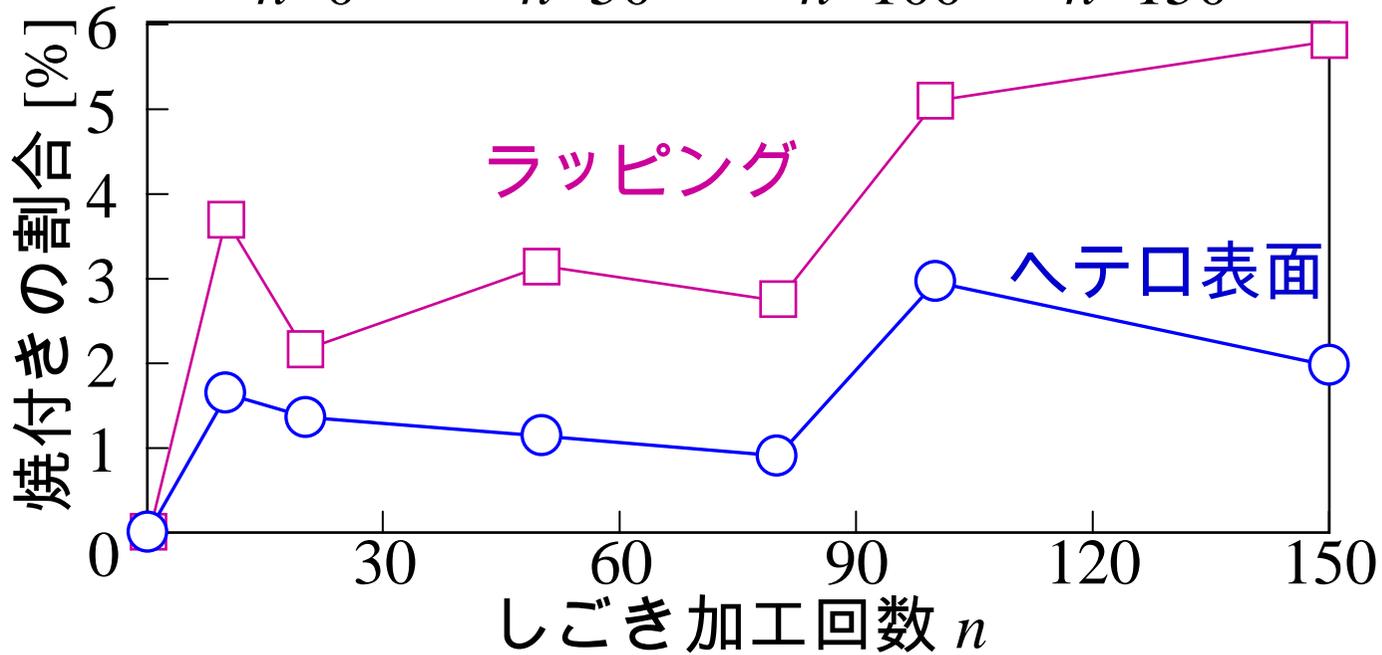
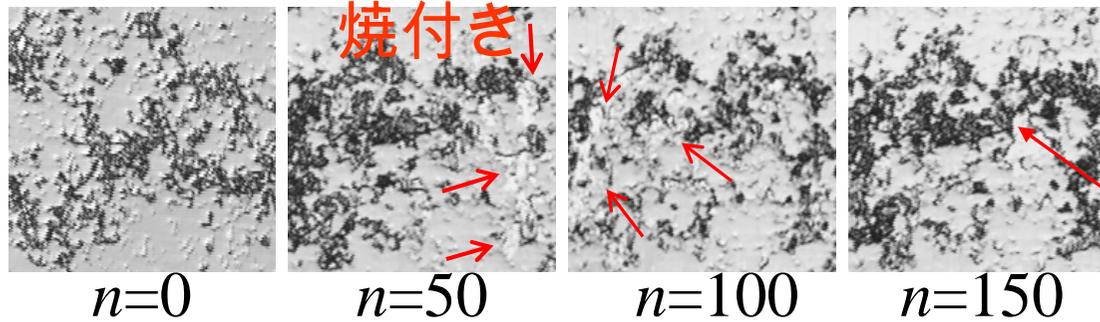
20 μ m



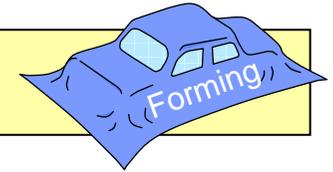
観察部



ヘテロ表面

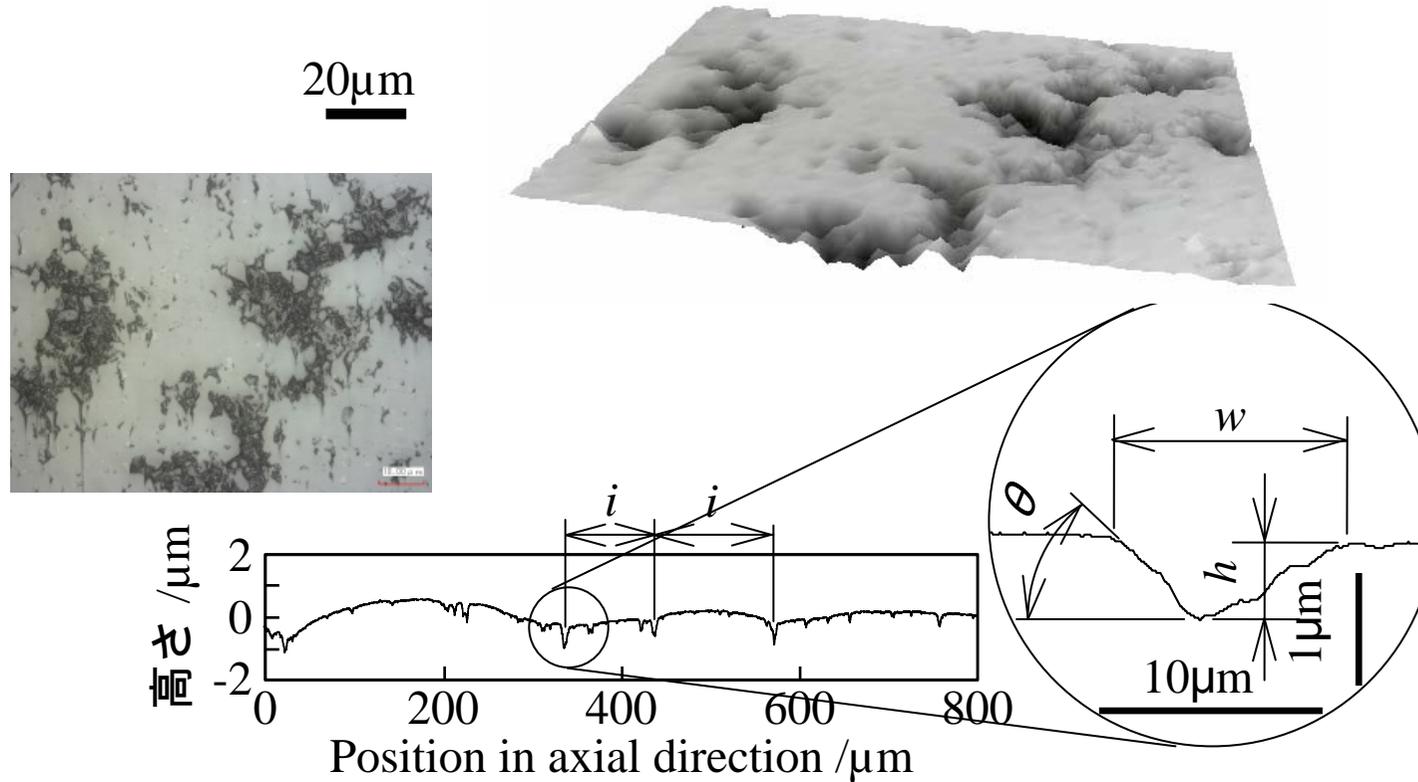


まとめ



- 1) ヘテロ表面では $0.05\mu\text{mRa}$ から $0.12\mu\text{mRa}$ の範囲でラッピングされた表面よりも限界が高くなっており，最適なヘテロ表面ダイによって焼付き限界を向上できた．
- 2) いずれの表面においてもしごき率とともに摩擦係数が増加してたが，ヘテロ表面，ショットピーニングのみの表面，ラッピングされた表面の順で低くなっており，ヘテロ表面の高潤滑により摩擦力が低減していると考えられる．
- 3) 平らな部分と潤滑ポケットから構成されるヘテロ表面では，潤滑ポケットによって潤滑膜が厚くなるとともに，ダイ表面の凸部がないために容器とダイの接触が抑制されて高潤滑になっているようであった．
- 4) ヘテロ表面ダイによってSUS304容器とA3003容器に対しても焼付き限界が向上できた．

有効なヘテロ表面形状



潤滑剤ポケット深さ h / μm	0.4~1.0
潤滑剤ポケット幅 w / μm	9~15
潤滑剤ポケット間平均距離 i / μm	50~200
潤滑剤ポケットのエッジの角度 θ / $^\circ$	5~15
潤滑剤ポケット面積の割合 /%	25~30