



SAPIENZA  
UNIVERSITÀ DI ROMA

**AIAS 2008**

XXXVII CONVEGNO NAZIONALE



# **Problematiche di misura delle tensioni residue con il metodo del foro nei pressi della superficie**

Autori:

Leonardo BERTINI

Marco BEGHINI

Ciro SANTUS

Emilio VALENTINI

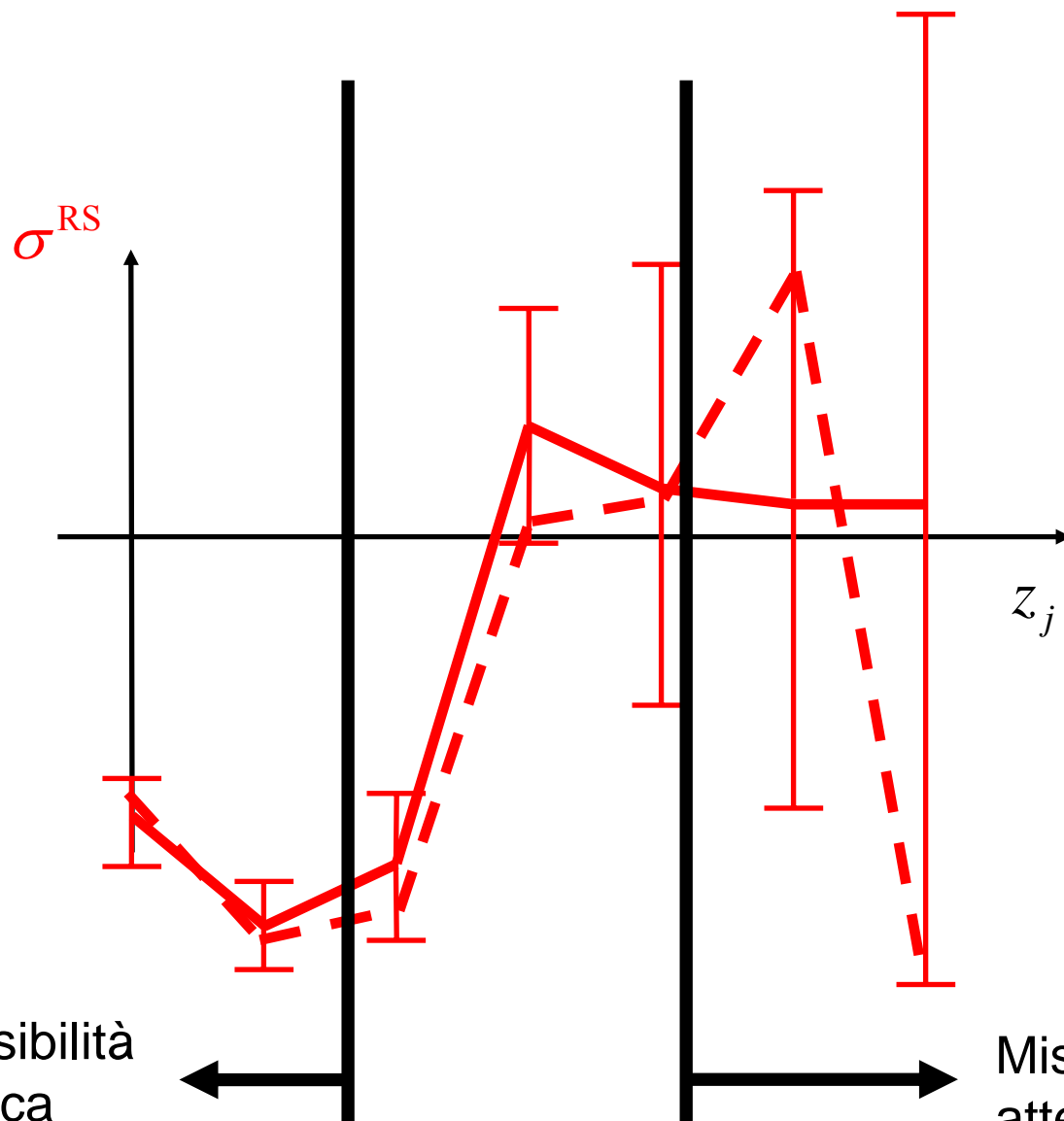
Alessio BENINCASA

DIMNP Università di Pisa

SINT Technology (FI)



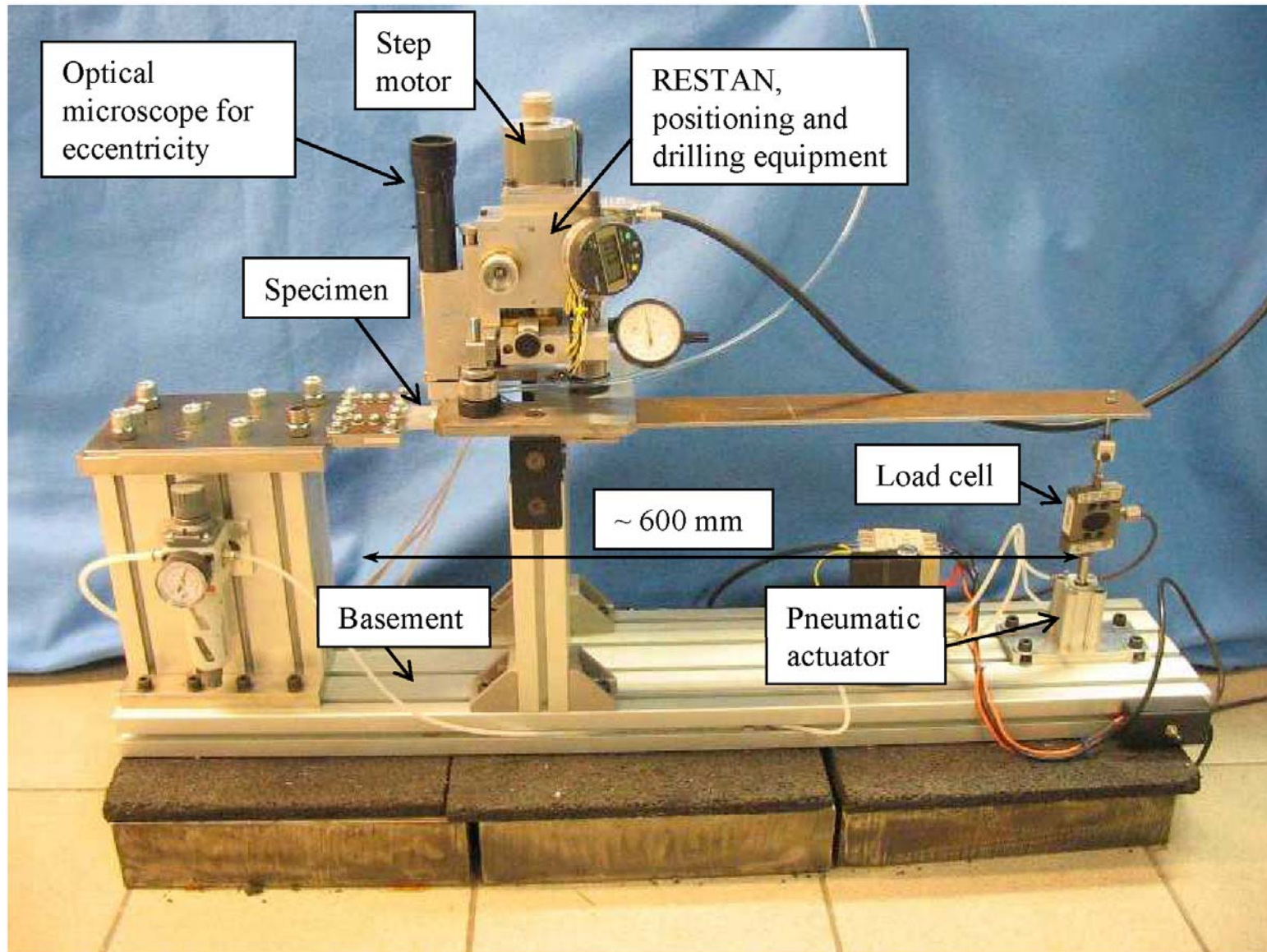
# Metodo del foro, profondità



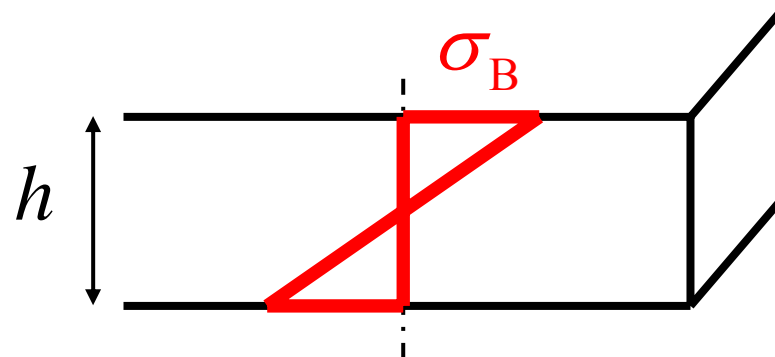
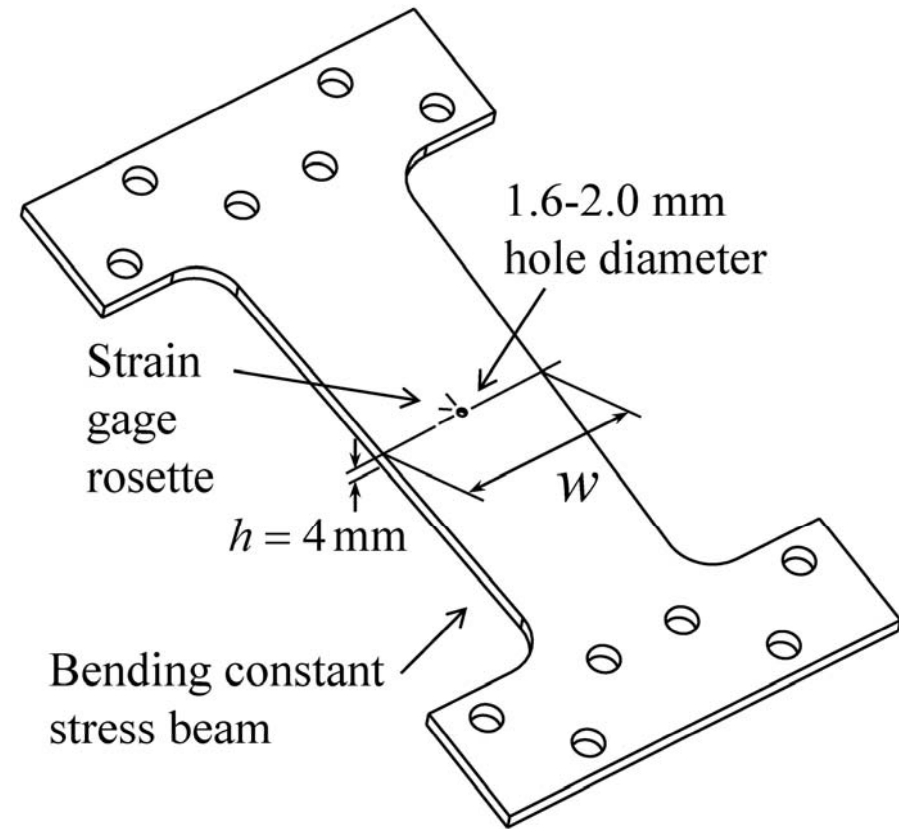
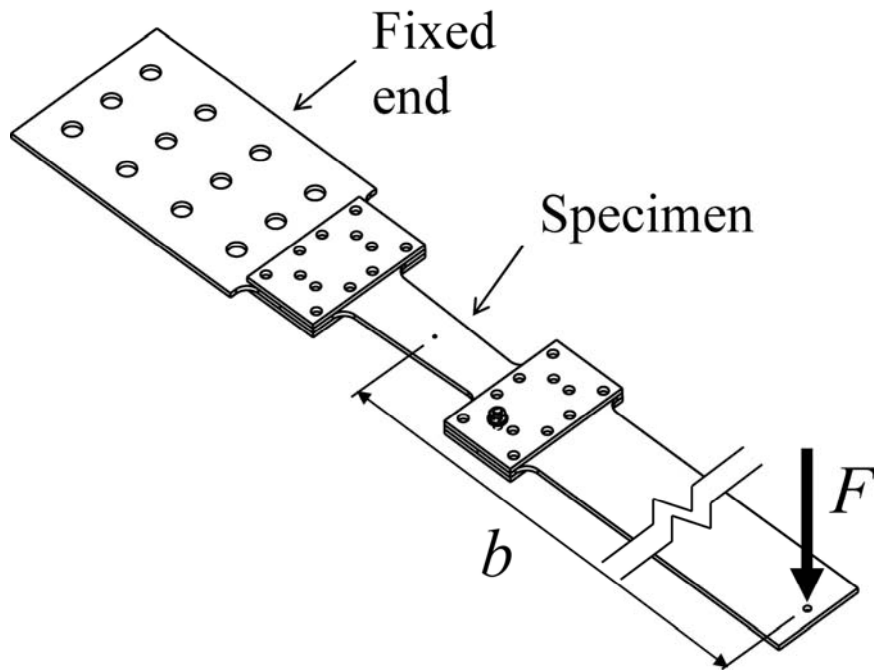
Elevata sensibilità  
estensimetrica  
Misura corretta ???

Misura non  
attendibile  
>  $0.5 D_0$  (circa)

# Banco di flessione

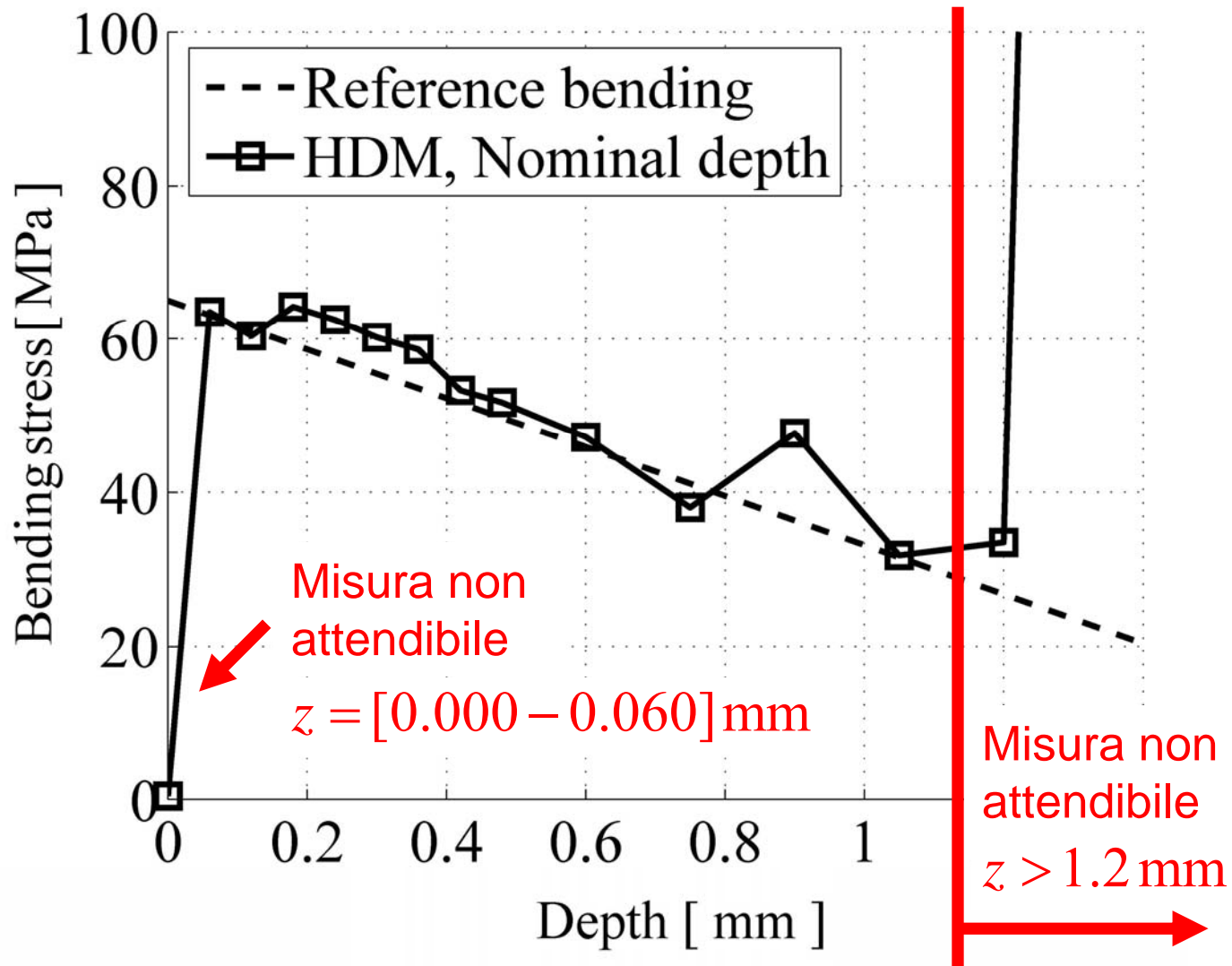


# Tensione di flessione nota



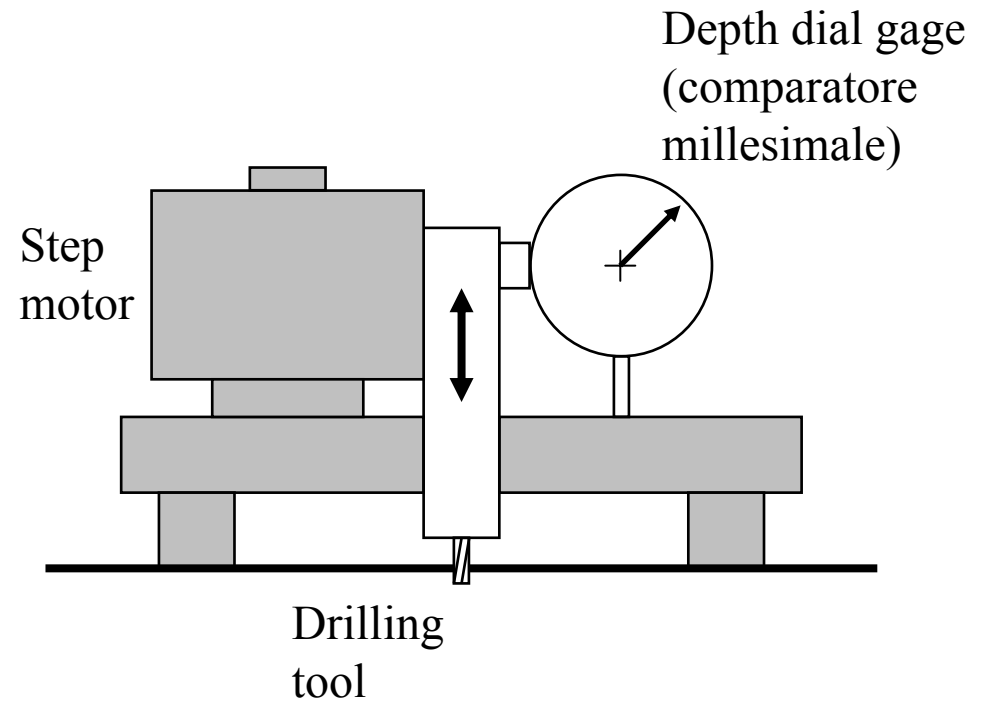
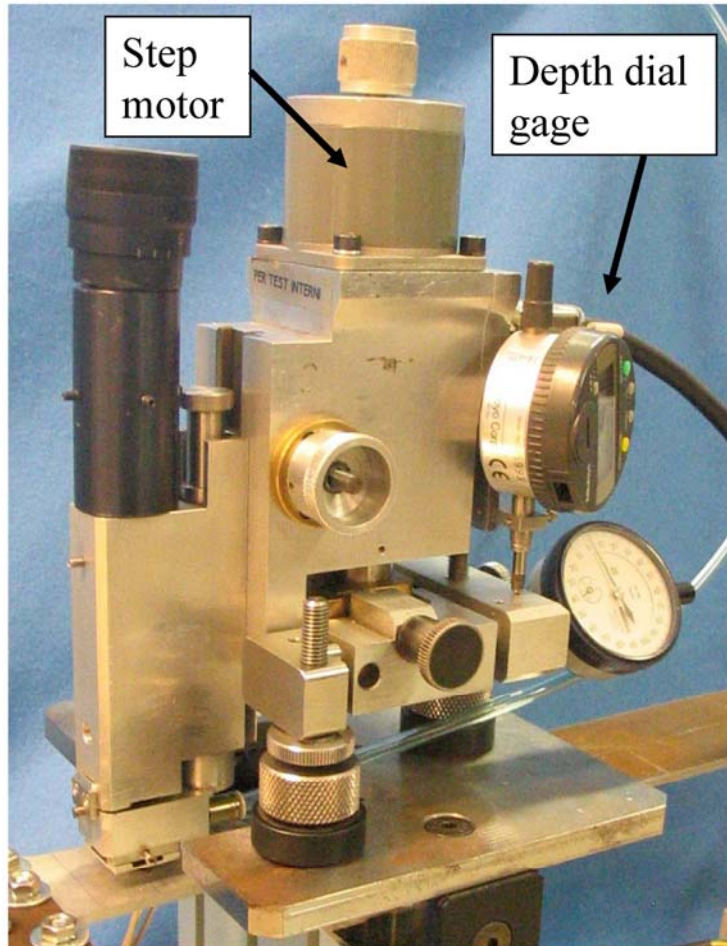
$$\sigma_B = 6 \frac{F b}{w h^2}$$

# Misura mediante il metodo del foro della tensione di flessione nota



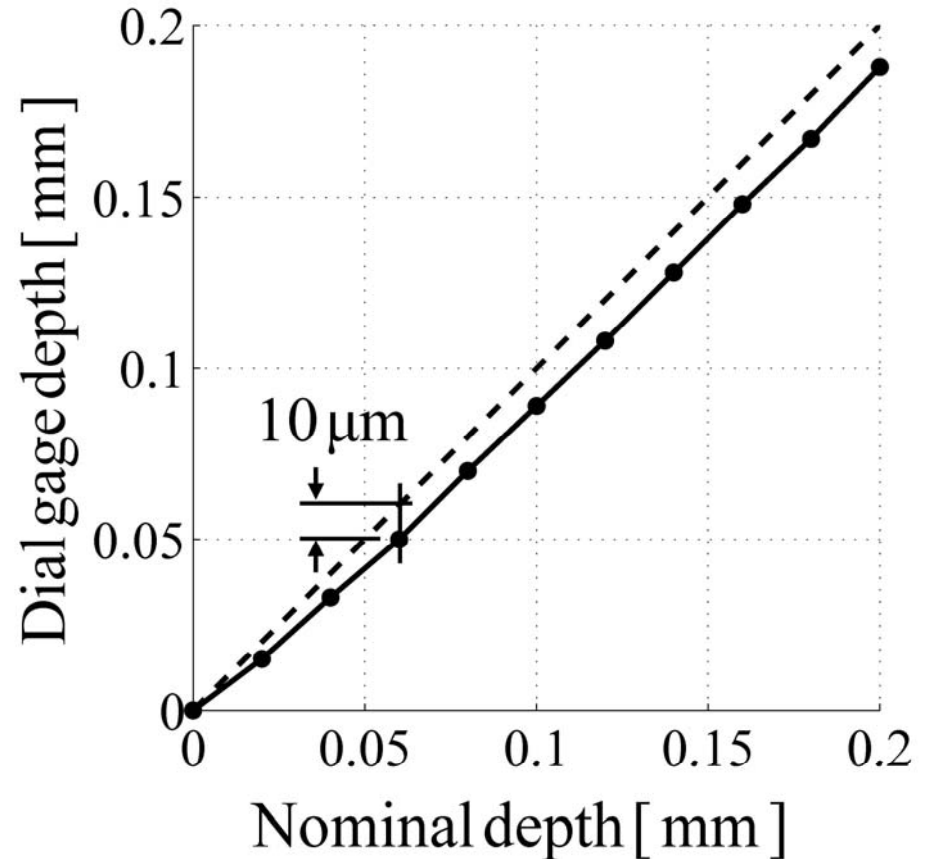
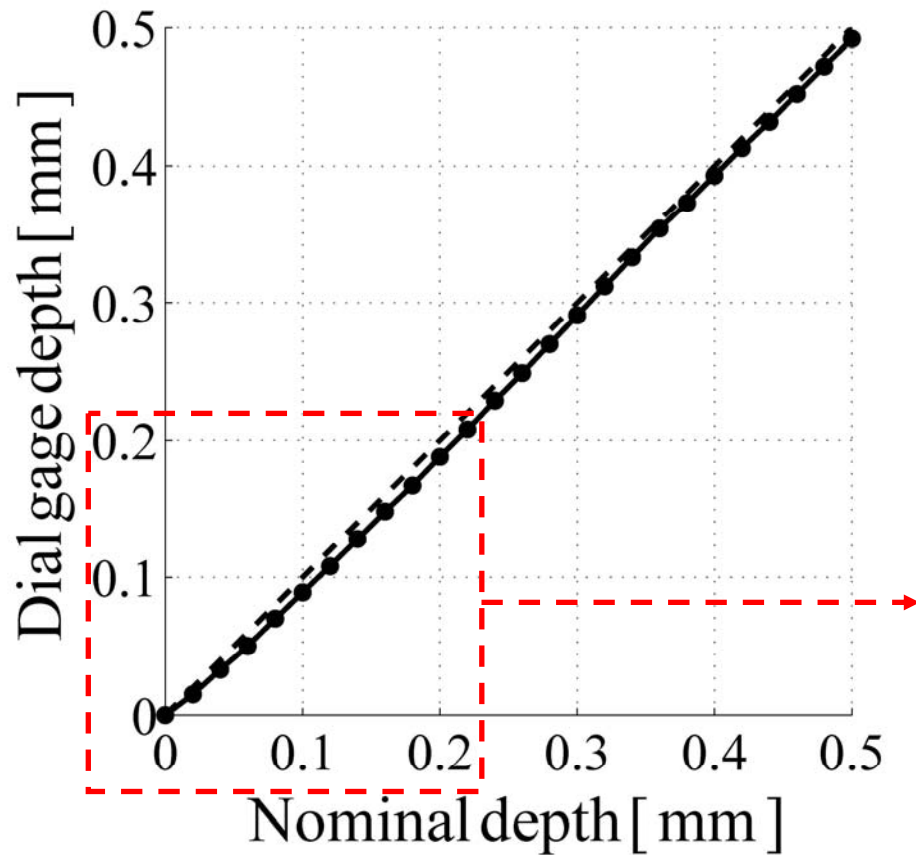
# Cause dell'errore di misura a bassa profondità

Profondità nominali / profondità effettive

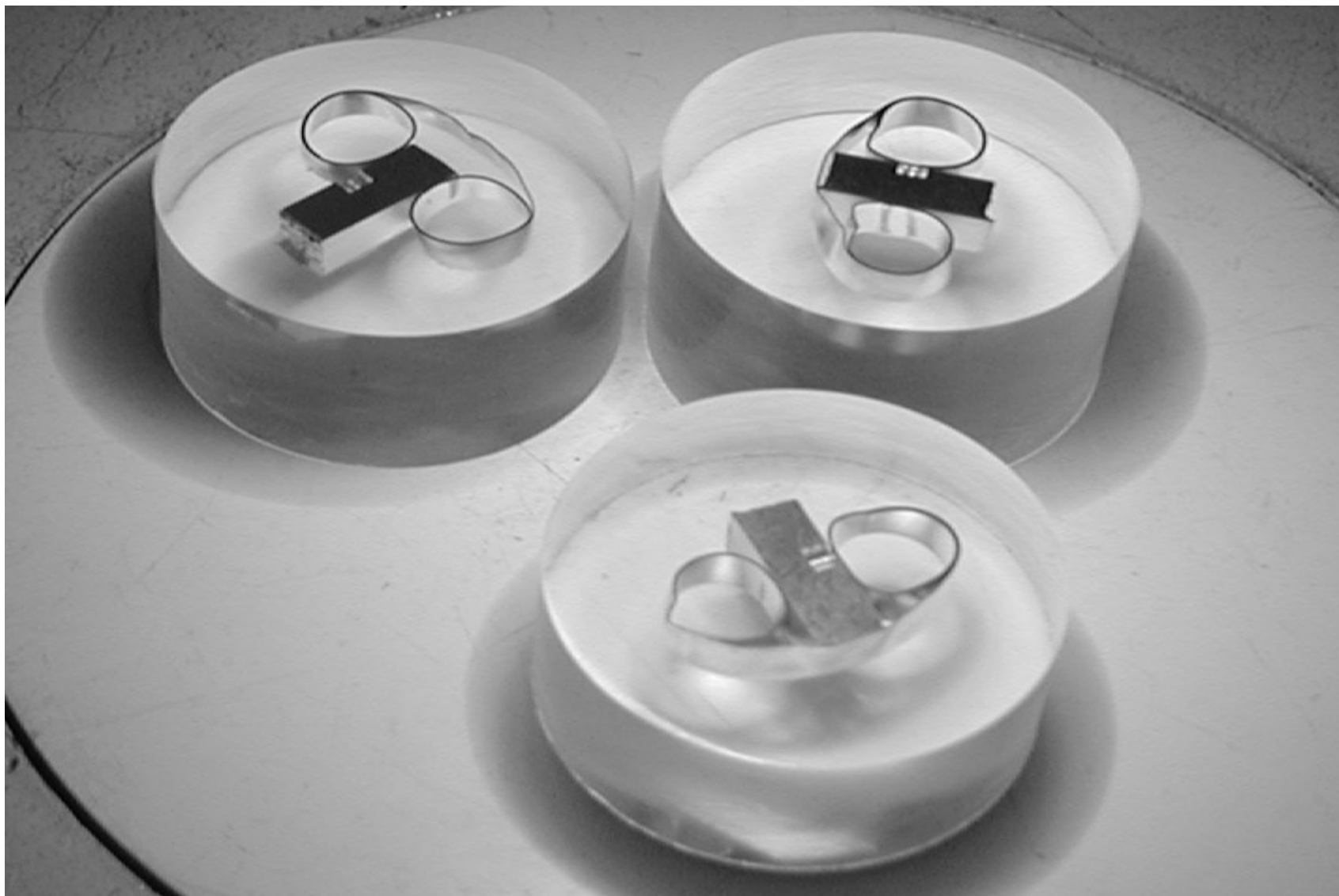


# Cause dell'errore di misura a bassa profondità

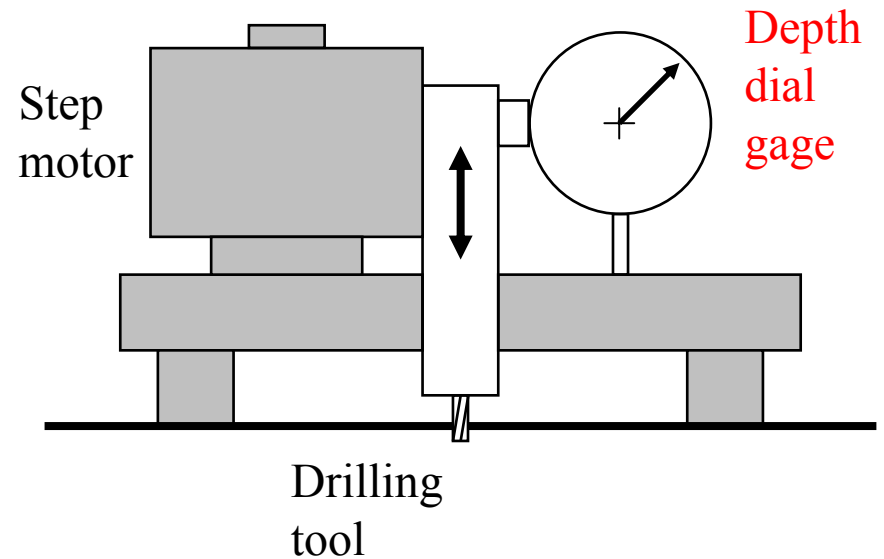
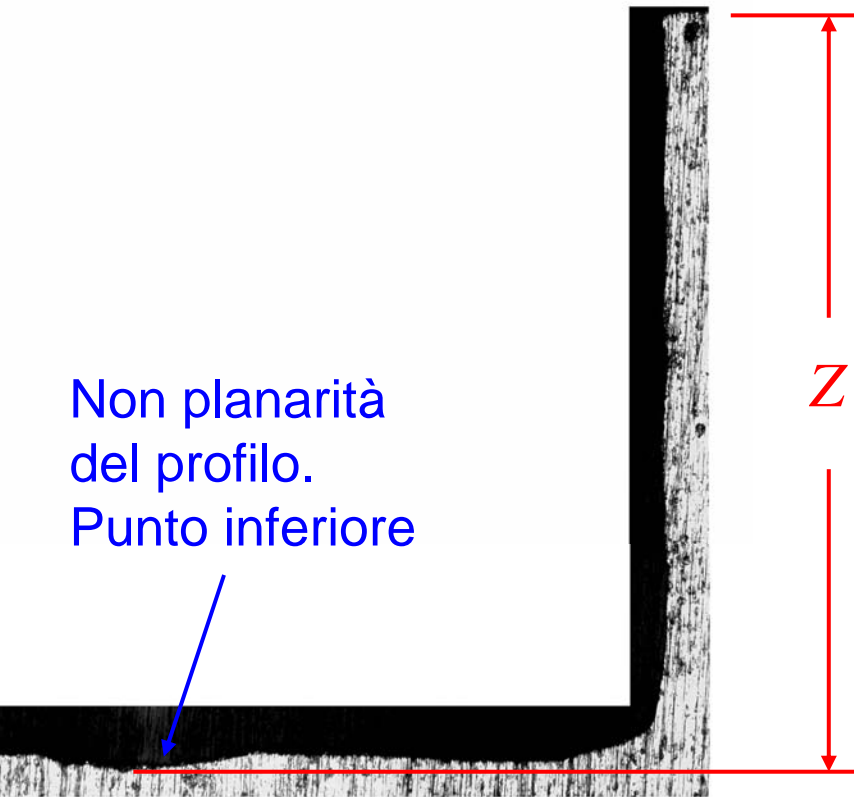
Profondità nominali / profondità effettive



# Zero setting, effettiva profondità e profilo dei fori



# Verifiche profondità



Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]	Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]
1	0.020	0.016	0.019	3	0.100	0.095	0.094
2	0.060	0.050	0.050	4	0.100	0.088	0.090

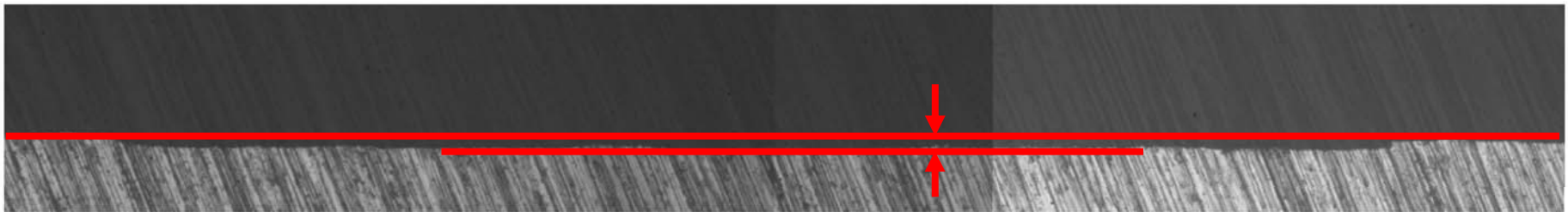
# Verifiche profondità

$$Z(\text{nominal}) = 20 \mu\text{m}$$

$$Z(\text{dial gage}) = 16 \mu\text{m}$$

$$Z(\text{microscope}) = 19 \pm 2 \mu\text{m}$$

500  $\mu\text{m}$



Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]	Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]
1	0.020	0.016	0.019	3	0.100	0.095	0.094
2	0.060	0.050	0.050	4	0.100	0.088	0.090

# Verifiche profondità

$$Z(\text{nominal}) = 60 \mu\text{m}$$

$$Z(\text{dial gage}) = 50 \mu\text{m}$$

$$Z(\text{microscope}) = 50 \pm 2 \mu\text{m}$$

500  $\mu\text{m}$



Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]	Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]
1	0.020	0.016	0.019	3	0.100	0.095	0.094
2	0.060	0.050	0.050	4	0.100	0.088	0.090

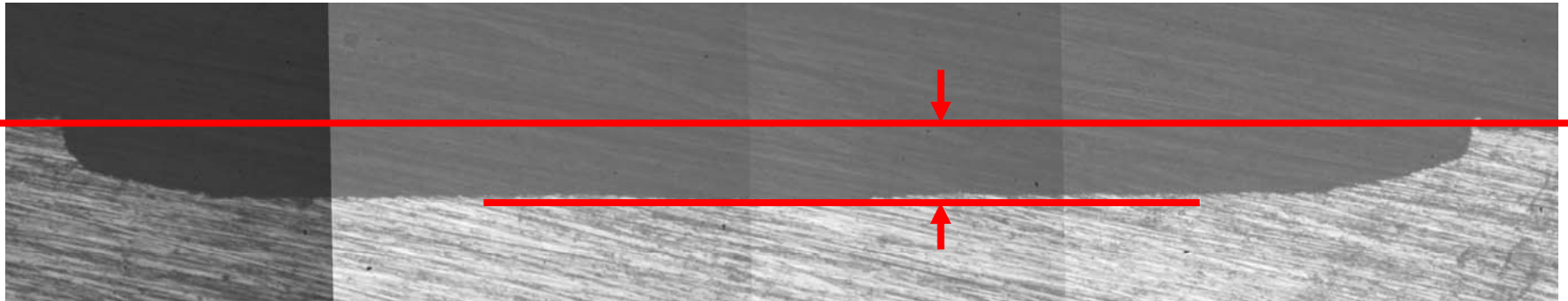
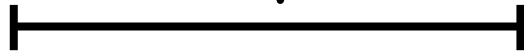
# Verifiche profondità

$$Z(\text{nominal}) = 100 \mu\text{m}$$

$$Z(\text{dial gage}) = 95 \mu\text{m}$$

$$Z(\text{microscope}) = 94 \pm 2 \mu\text{m}$$

500  $\mu\text{m}$



Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]	Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]
1	0.020	0.016	0.019	3	0.100	0.095	0.094
2	0.060	0.050	0.050	4	0.100	0.088	0.090

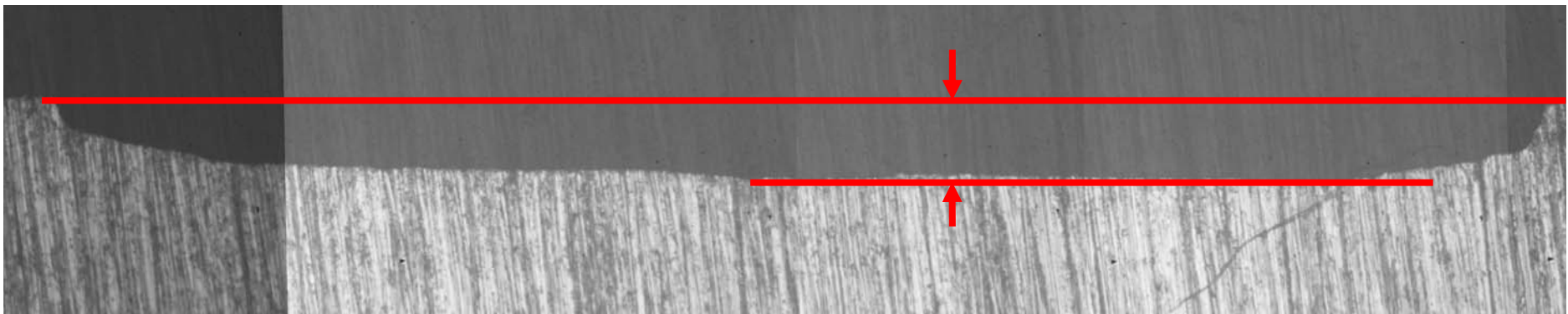
# Verifiche profondità

$$Z(\text{nominal}) = 100 \mu\text{m}$$

$$Z(\text{dial gage}) = 88 \mu\text{m}$$

$$Z(\text{microscope}) = 90 \pm 2 \mu\text{m}$$

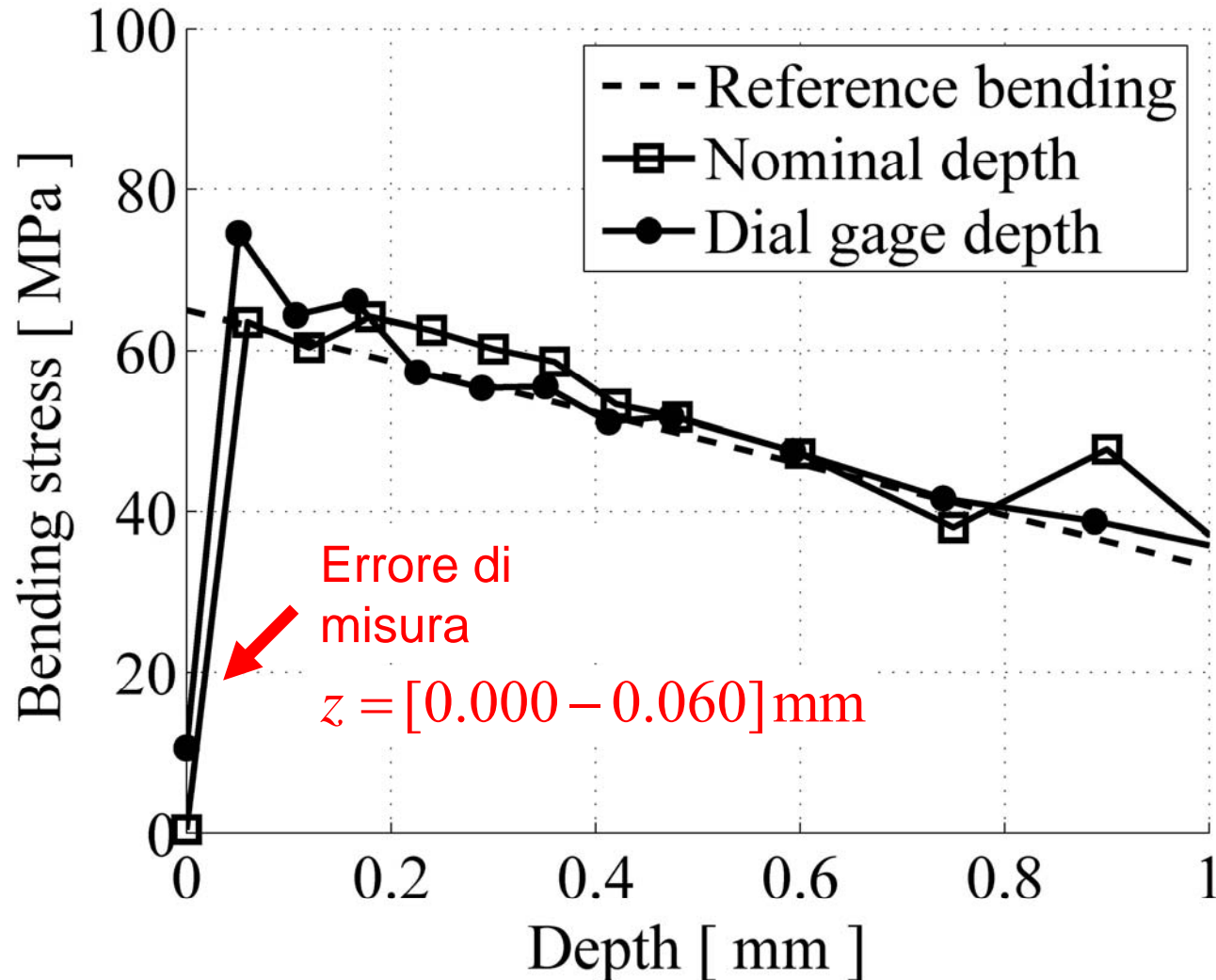
500  $\mu\text{m}$



Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]	Foro #	Nominale [ mm ]	Comparatore [ mm ]	Microscopio [ mm ]
1	0.020	0.016	0.019	3	0.100	0.095	0.094
2	0.060	0.050	0.050	4	0.100	0.088	0.090

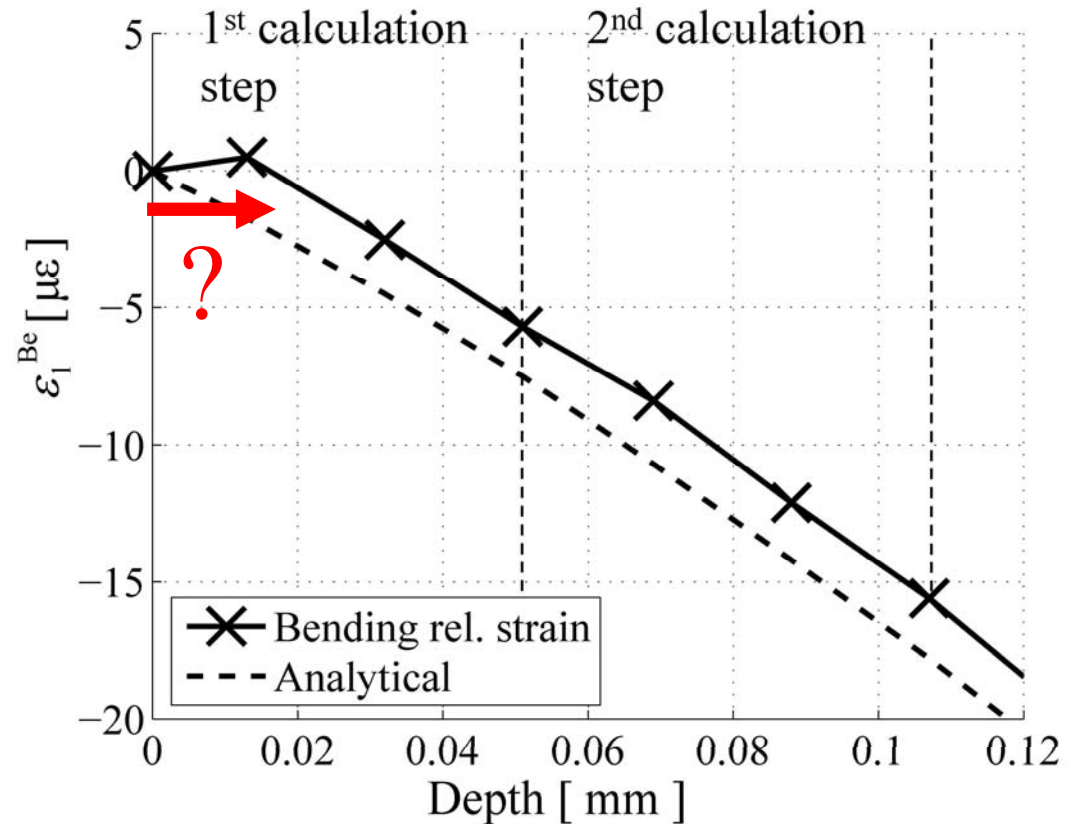
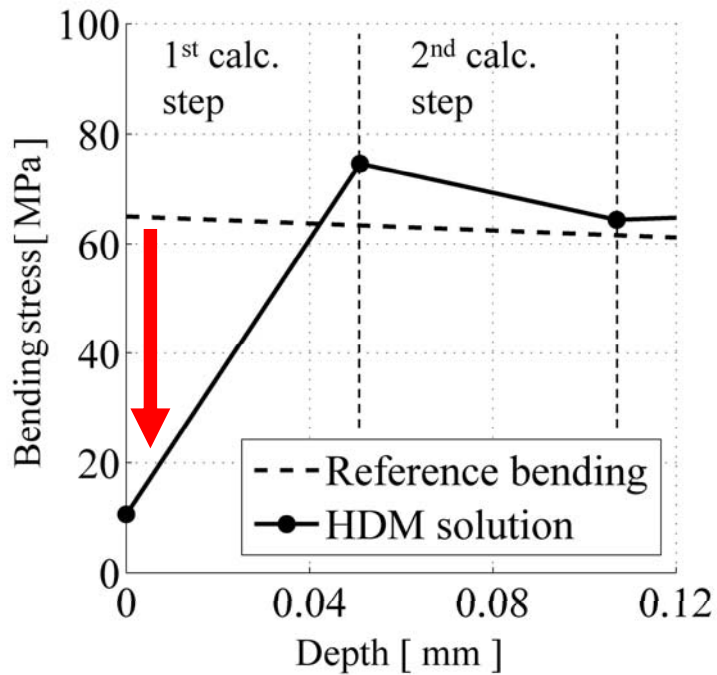
# Cause dell'errore di misura a bassa profondità

Profondità nominali / profondità effettive

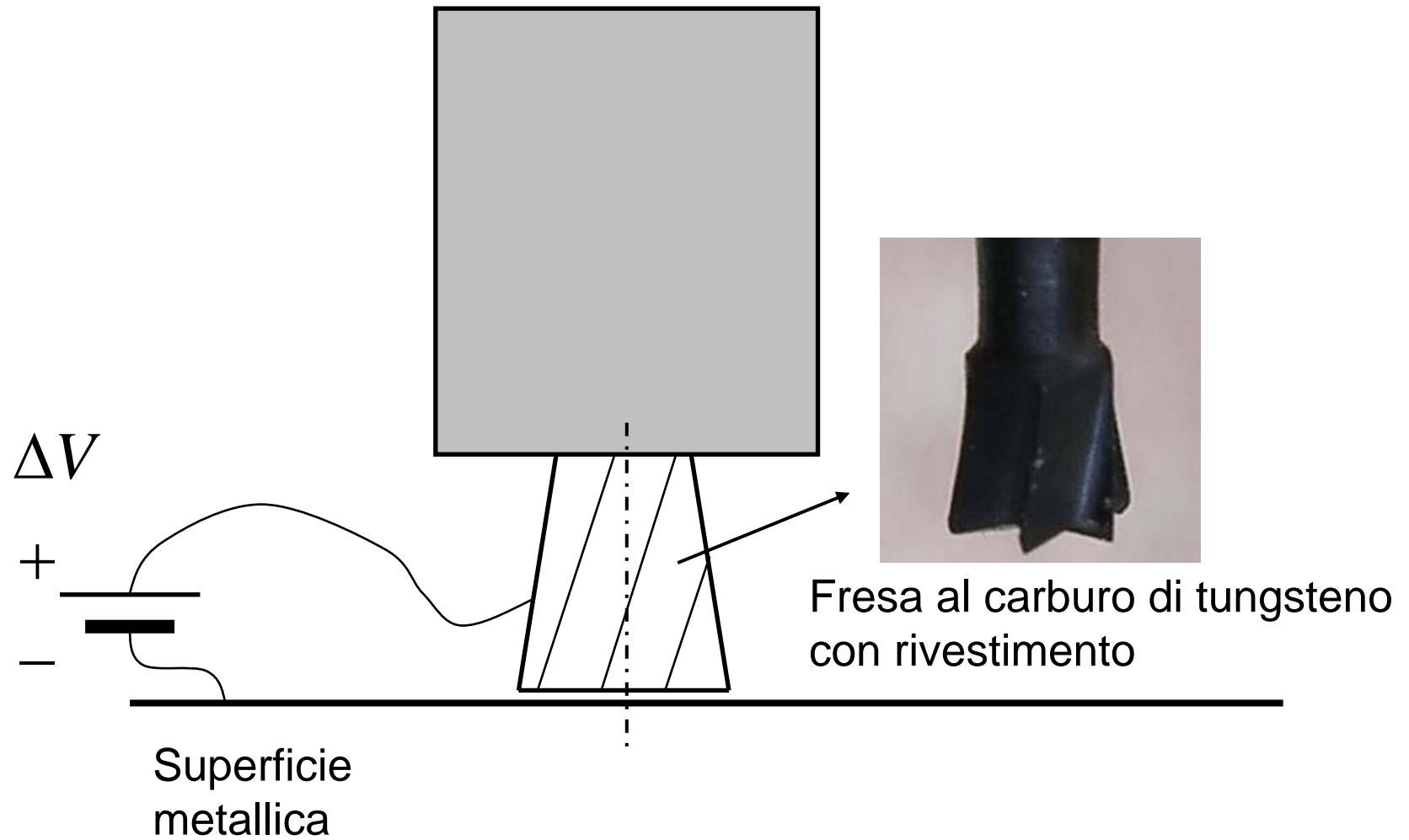


# Deformazioni rilasciate a bassa profondità

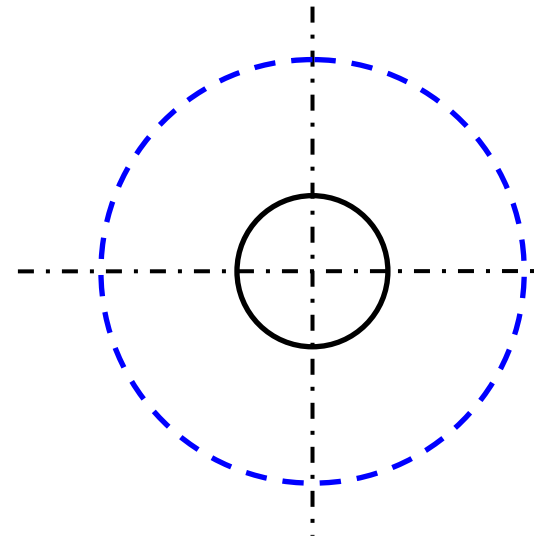
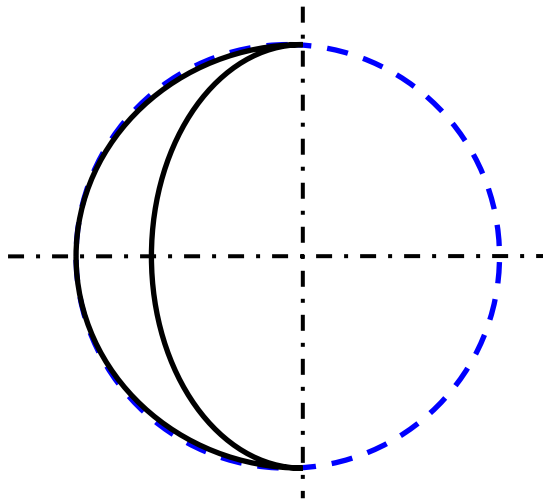
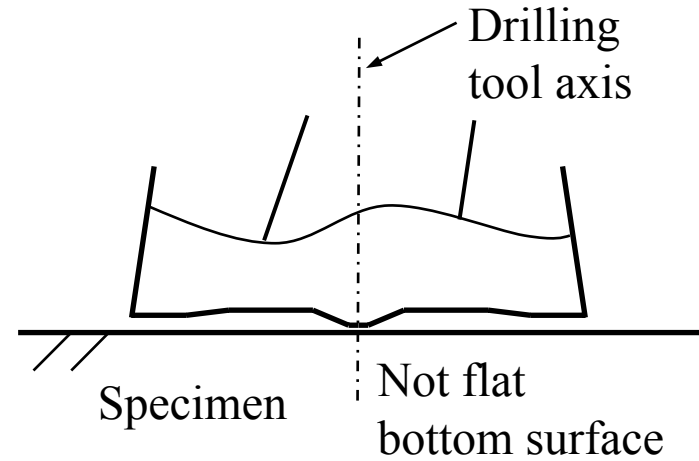
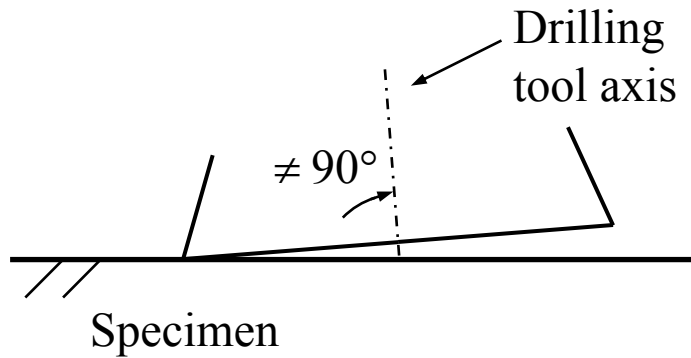
Ritardo in profondità delle deformazioni rilasciate



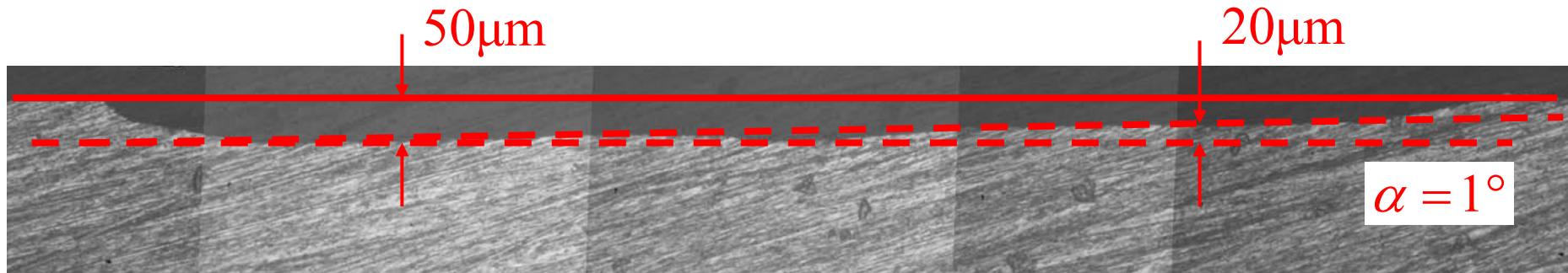
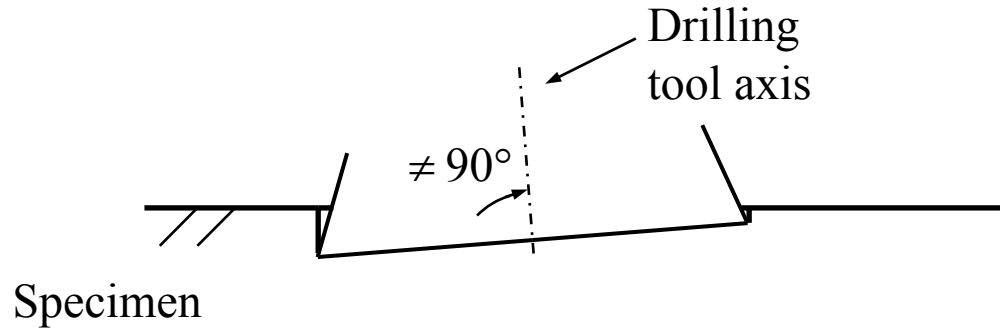
# Zero setting, contatto elettrico



# Impronta in superficie allo 'zero setting' (profondità zero)

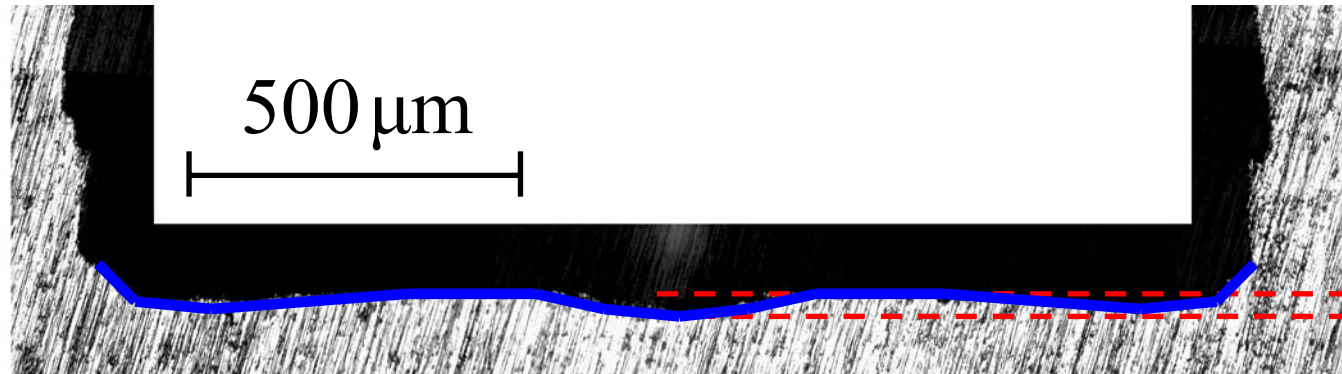
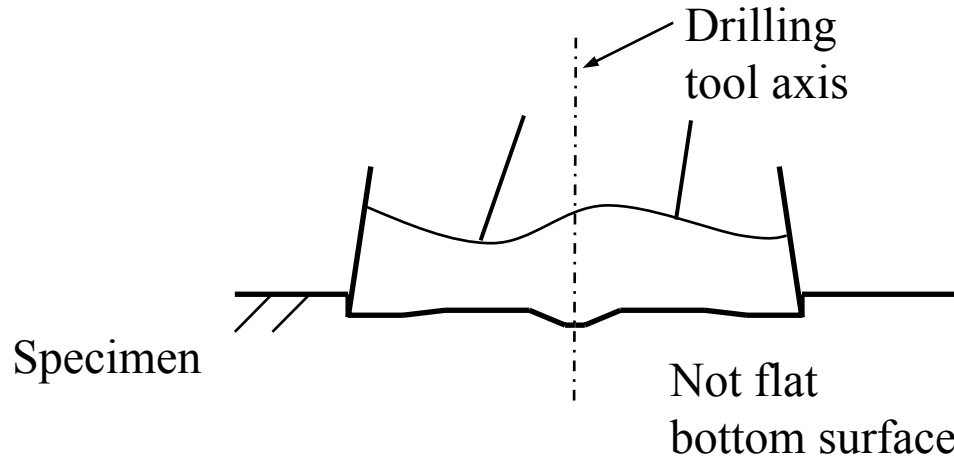


# Non perpendicolarità dell'asse



Minore volume asportato rispetto al cilindro ideale (eccentricità)

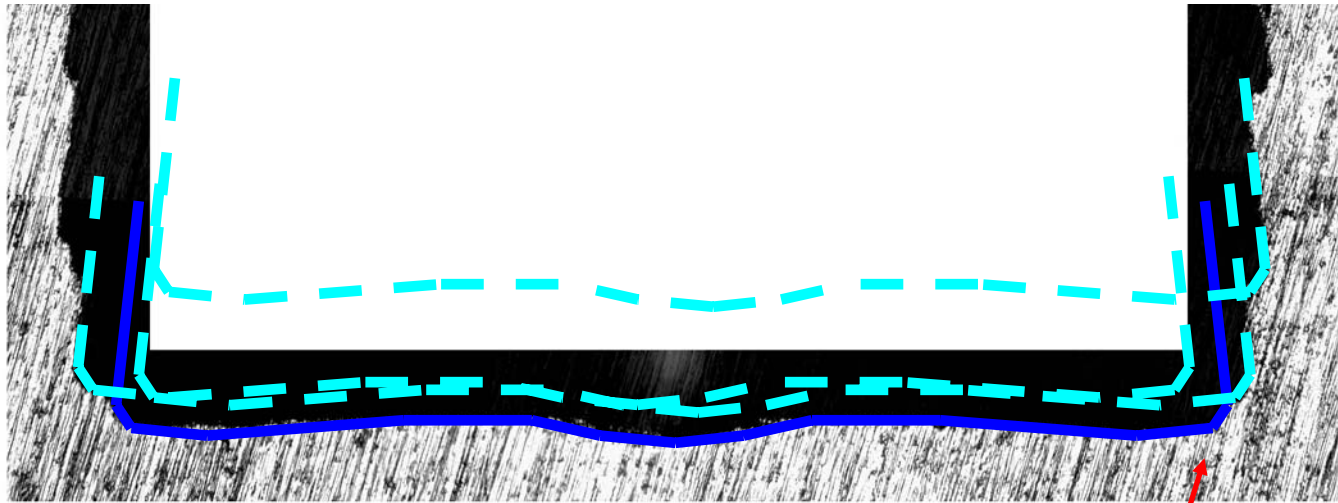
# Non planarità superficie inferiore tagliente



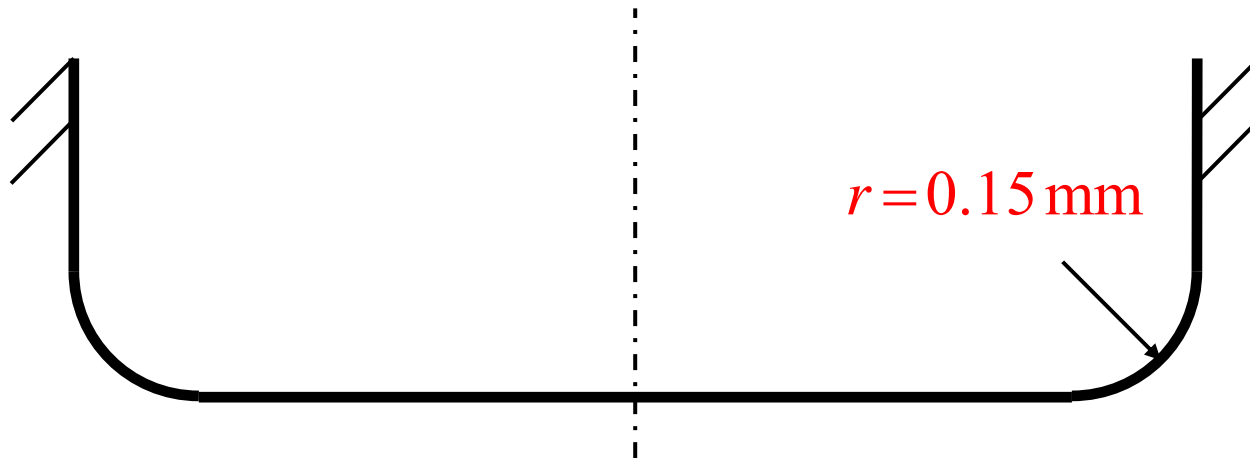
$$\Delta z_b = 40 \mu\text{m}$$

Minore volume asportato rispetto al cilindro ideale

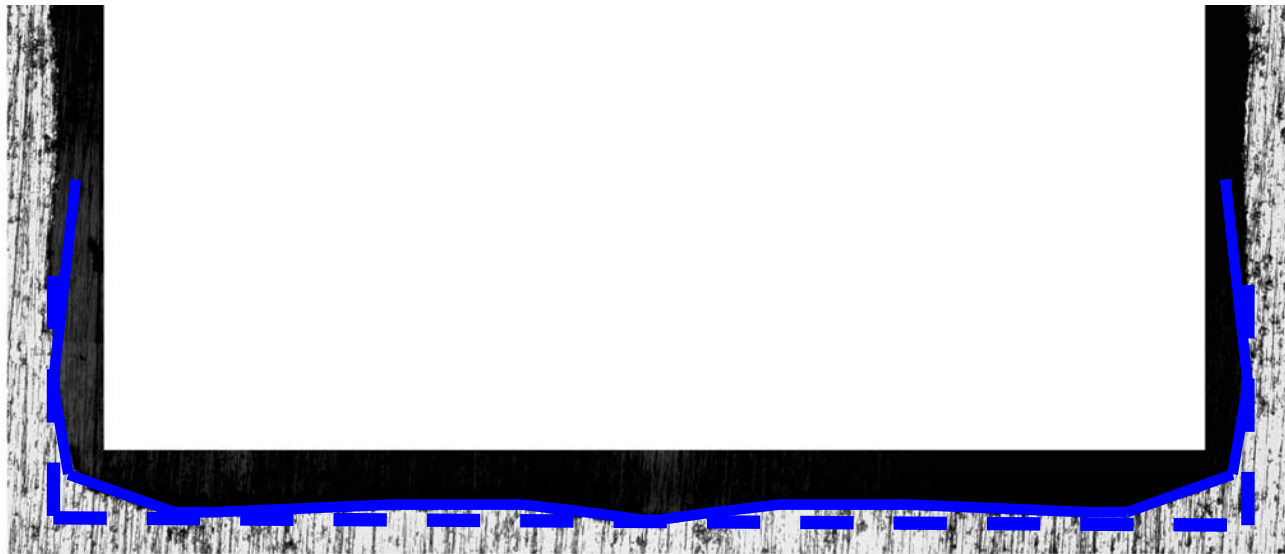
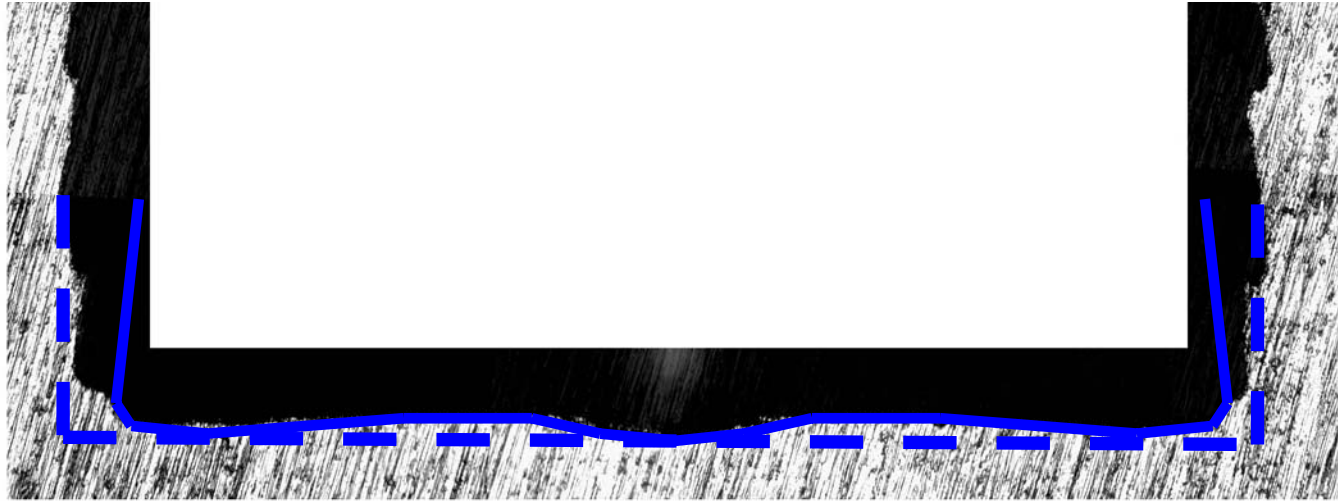
# Raccordo fra superficie inferiore e laterale



Approx. raccordo

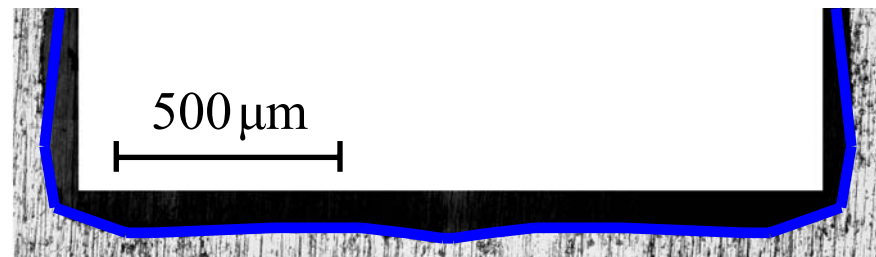


# Non ripetibilità dei profili

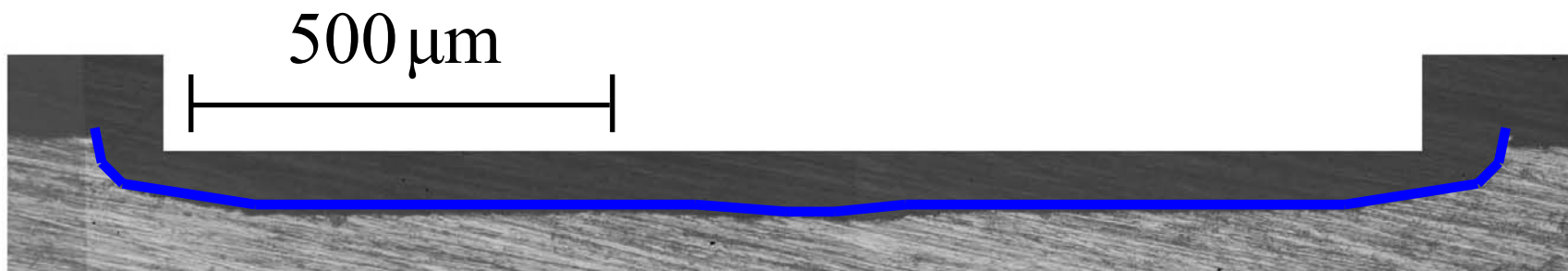


# Diversi tipi di tagliente

Tipo A,  $\phi_n = 1.6 \text{ mm}$



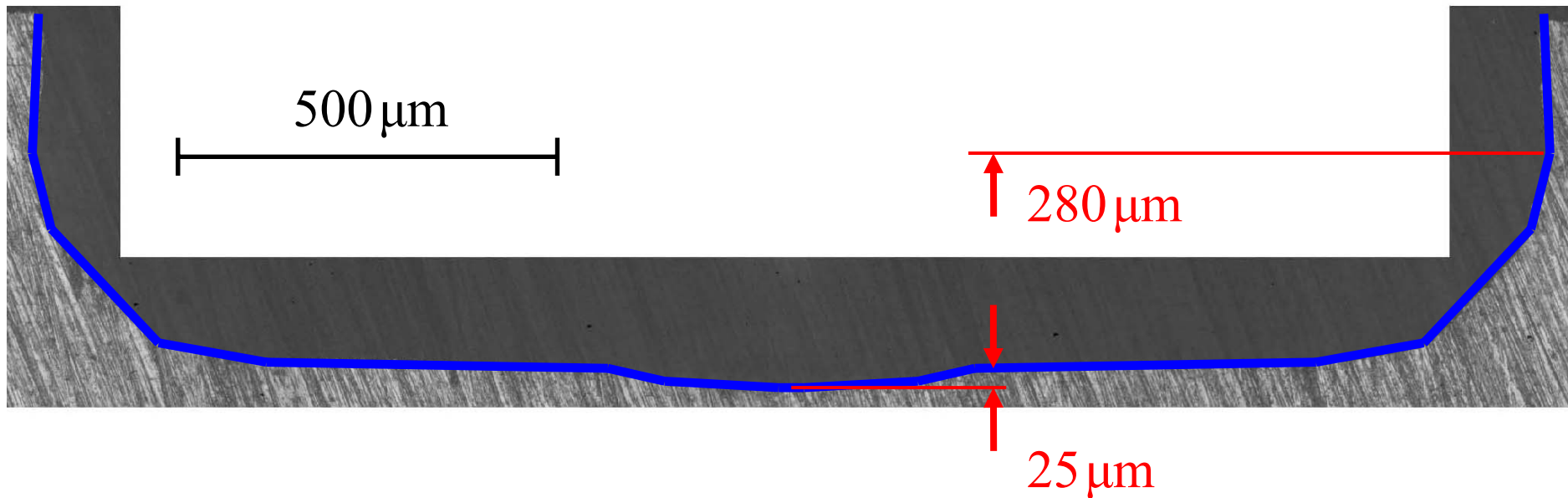
Tipo B,  $\phi_n = 1.2 \text{ mm}$



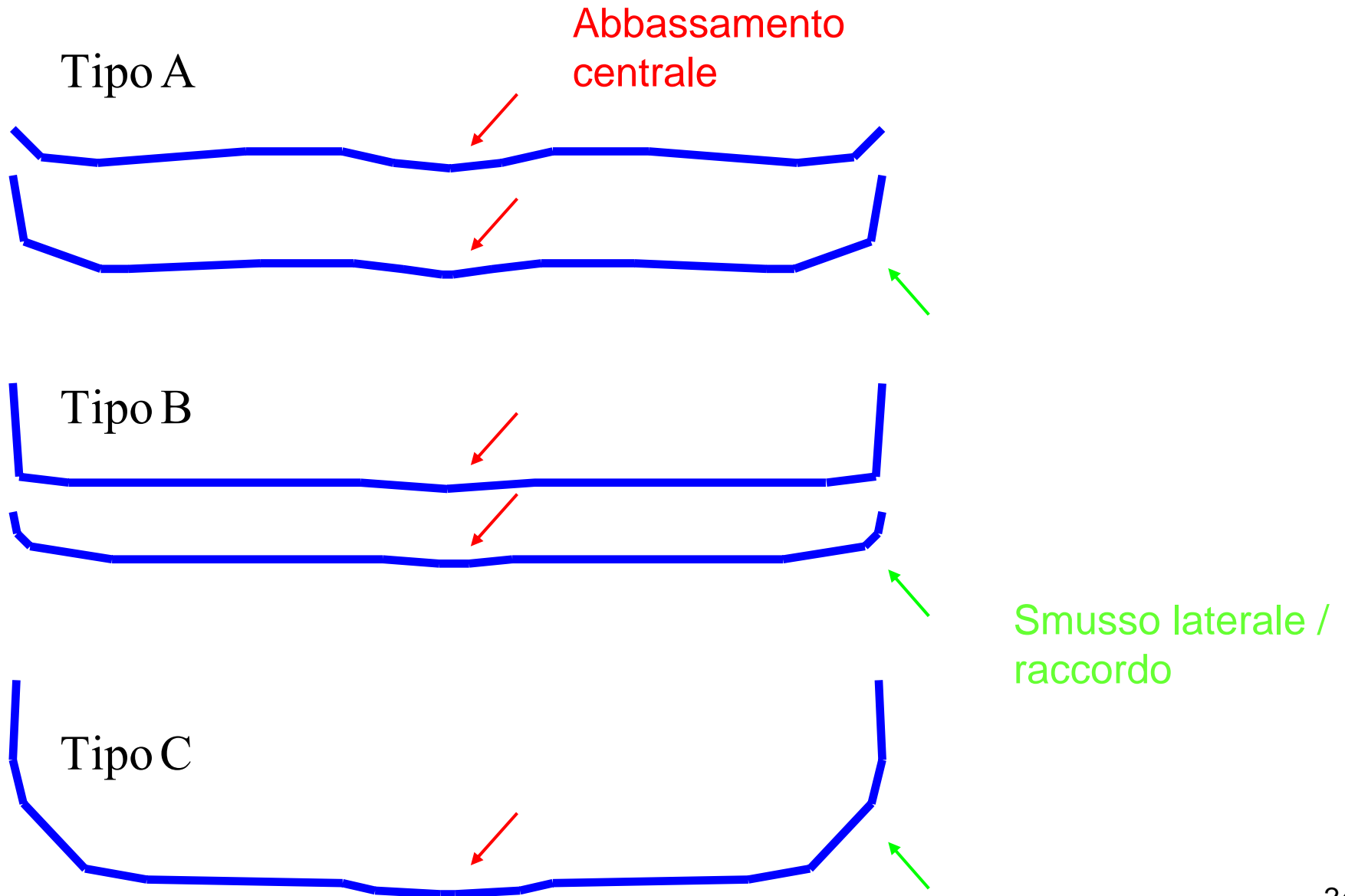
# Diversi tipi di tagliente

Tipo C,  $\phi_n = 1.6 \text{ mm}$

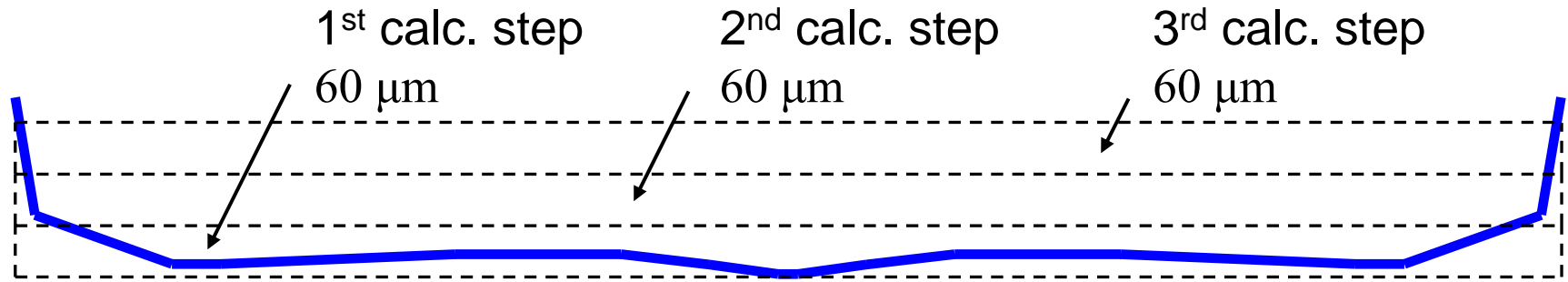
Smusso pronunciato, ottima penetrazione anche su materiali molto duri



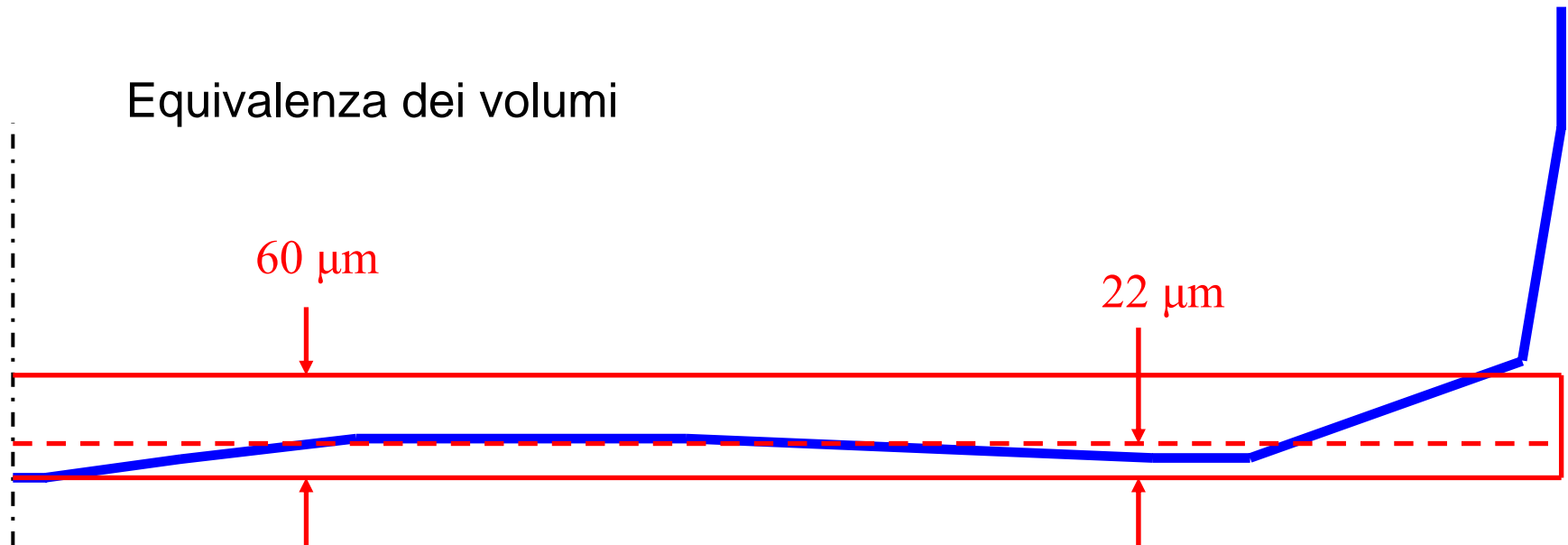
# Morfologia della superficie inferiore del tagliente



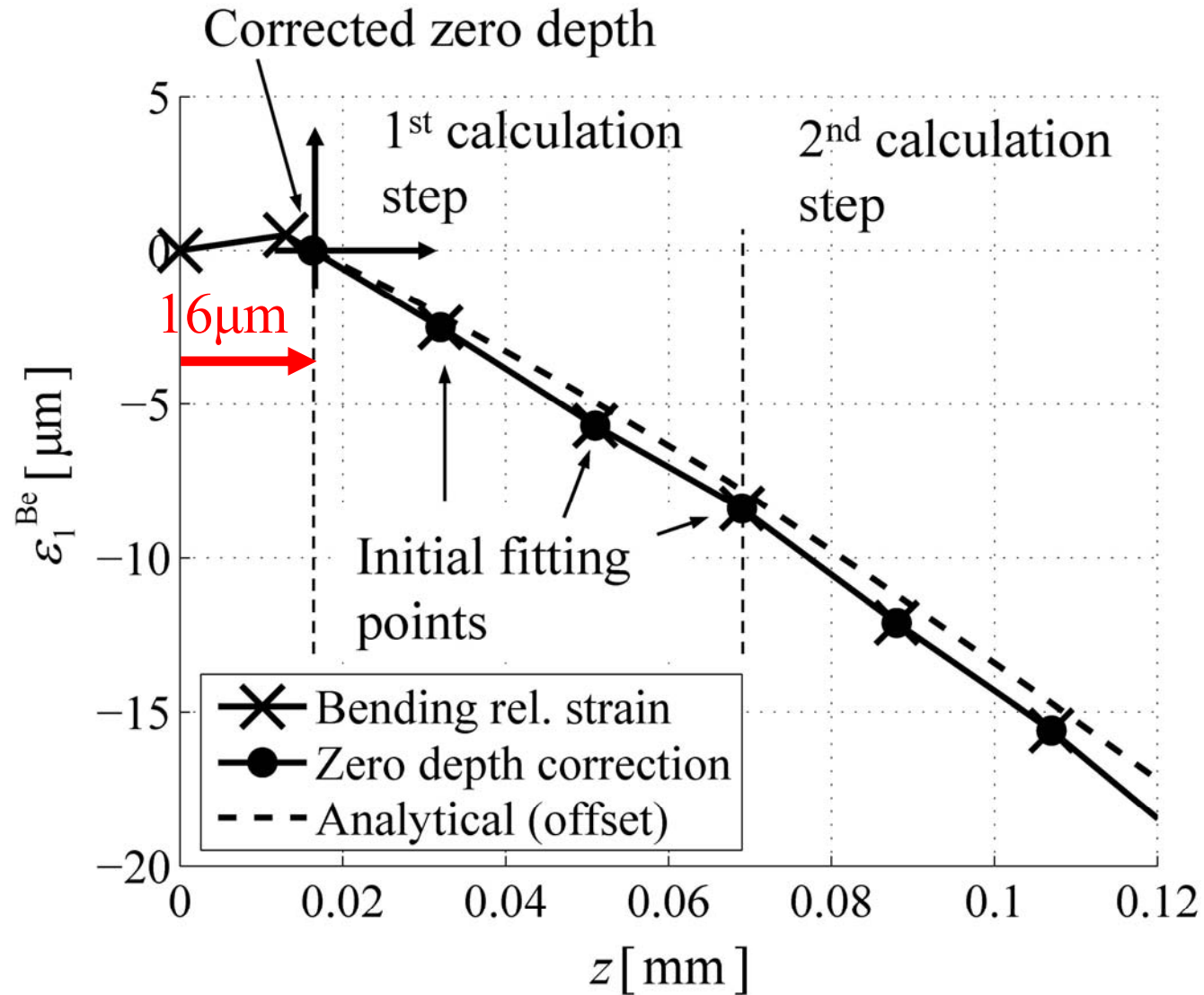
# Effettivo volume asportato per basse profondità



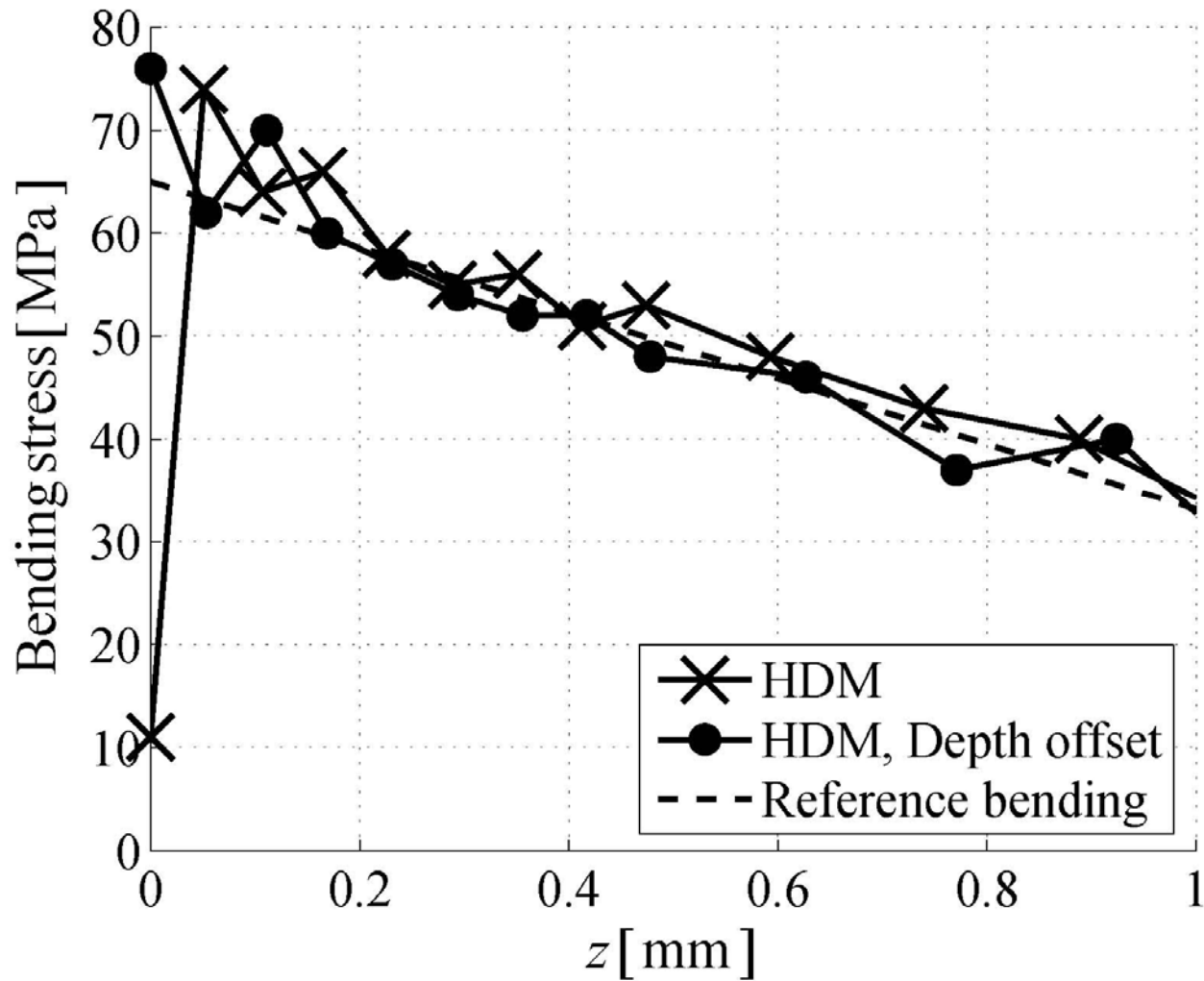
Minore volume asportato sul primo passo di calcolo



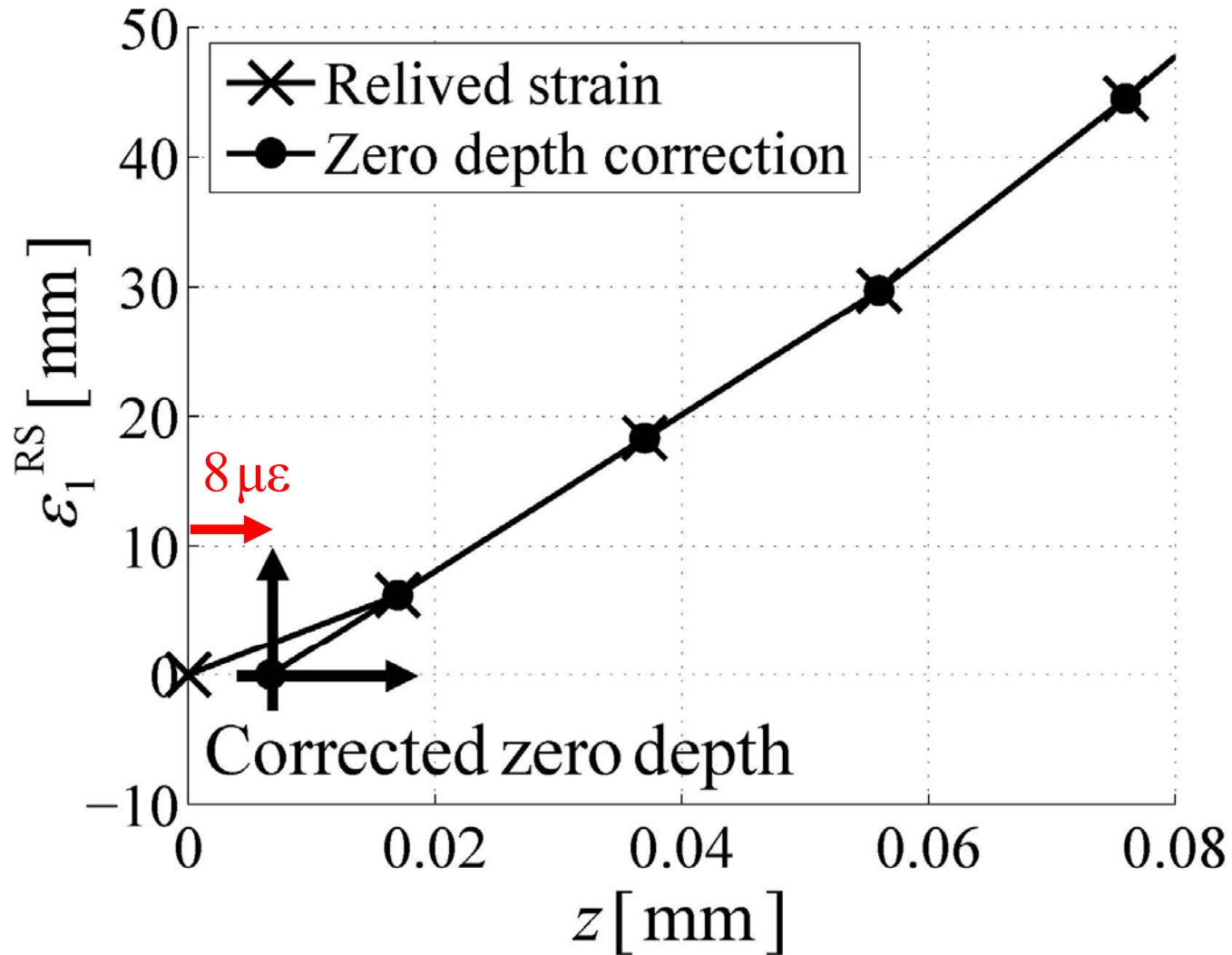
# Offset profondità



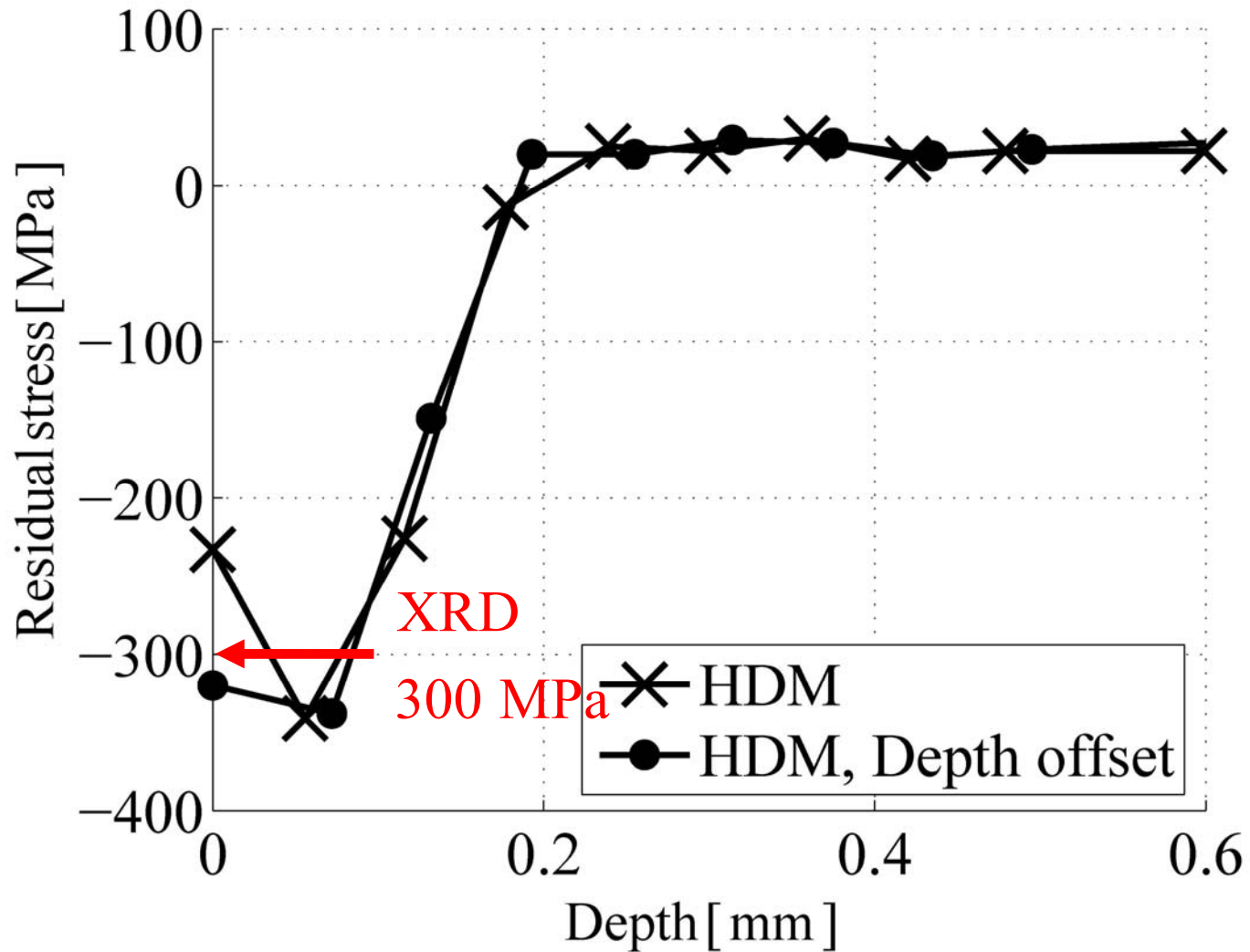
# Offset profondità, effetto sul risultato di tensione



# Offset profondità, tensioni residue



# Offset profondità, tensioni residue



# Conclusioni

- Sottostima (in modulo) delle tensioni a bassa profondità ( $< 0.060$  mm)
- Cause:
  - non perpendicolarità
  - **non planarità** della superficie inferiore del foro
- Correzione suggerita:
  - introdurre un **offset di profondità**, fit lineare sui primi valori delle deformazioni rilassate
  - maggiore risoluzione sui primi punti (ad esempio spaziatura di  $0.010$  mm)