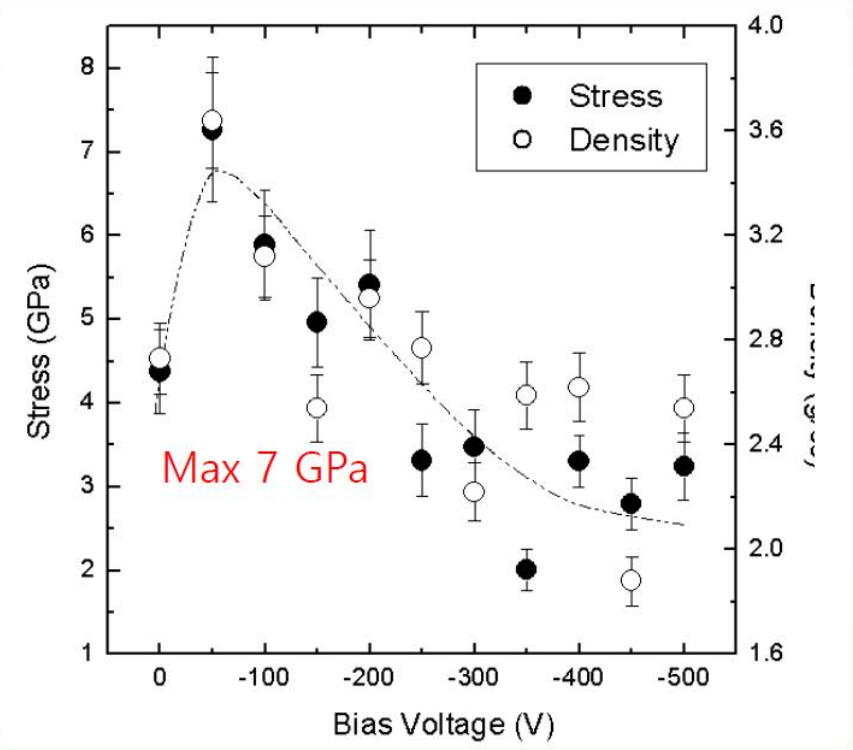
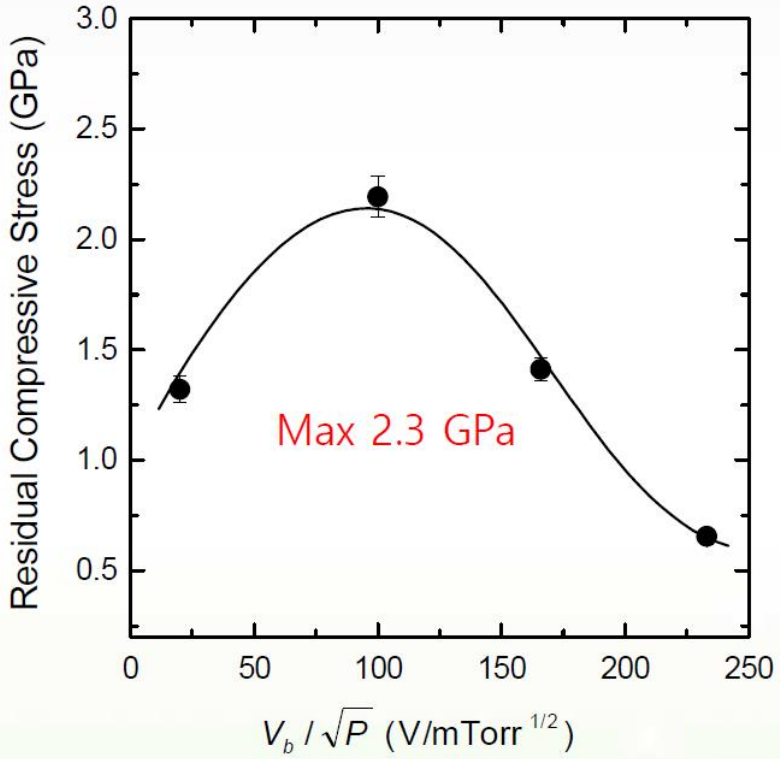
Stress

Typical Behavior of Residual Stress of DLC Films

ta-C by FVA > > a-C:H by rf-PACVD





Stress : Tensile stress & Compress stress (인장 응력, 압축 응력)

➔ Energy (Bias , Temperature, Pressure) ➔ Film Crystallization

Residual Stress of Thin Films

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- Thin films typically support very high stresses due to the constraint of the substrate to which they are attached
  - Normally at near failure stress!
  - Determines mechanical behaviors of the coating and devices (elastic distortion, plastic deformation, fracture, adhesion)

Substrate Interaction Stresses	Intrinsic Stresses
Relative Dimensional Change after Growth Thermal Stress Epitaxial Stress Interfacial Stress	Structure Evolution During Growth

Relative Dimensional Changes

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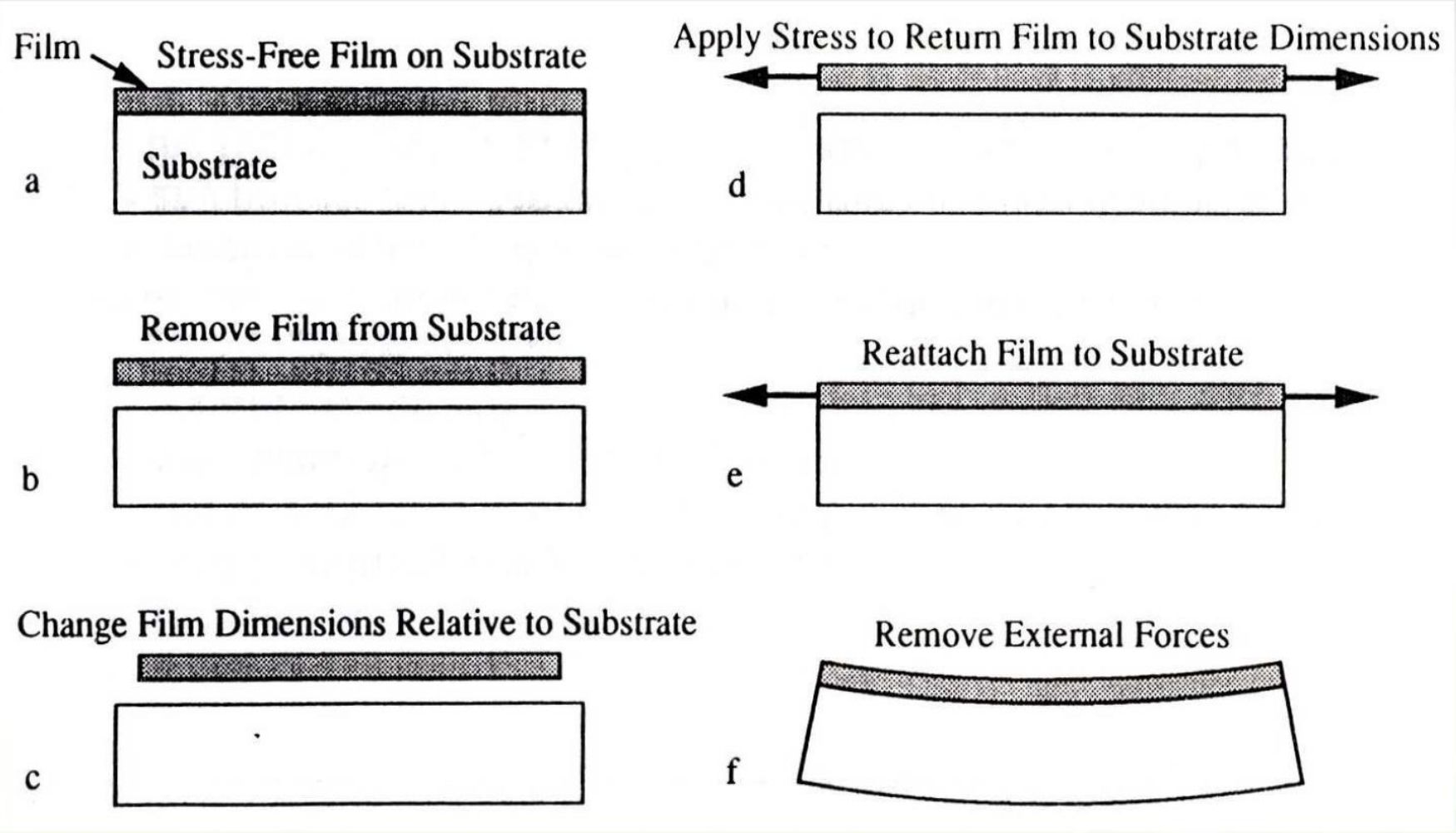

Condition : Adhesion between film and substrate

Any process that changes the in-plane dimension of the film relative to that of the substrate

Film Stress (Thicken : 후막화)

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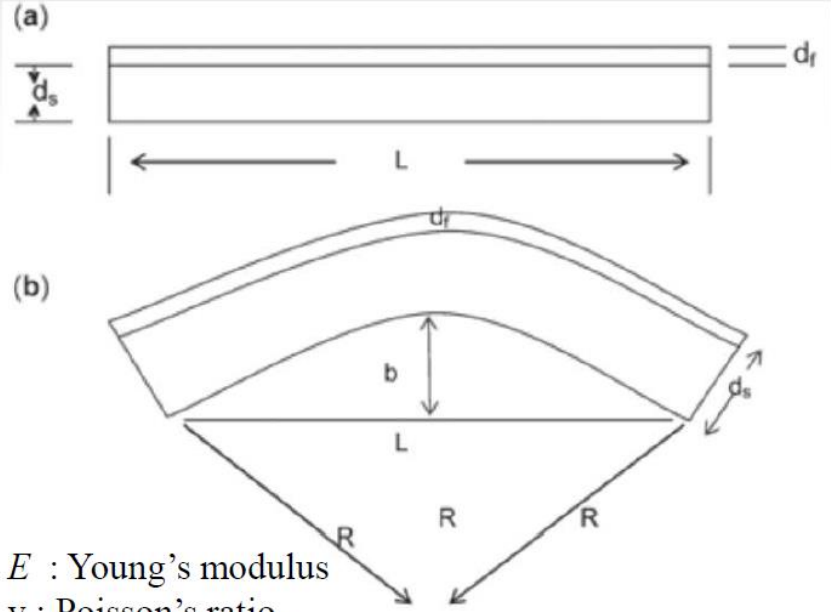


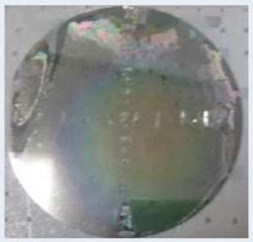
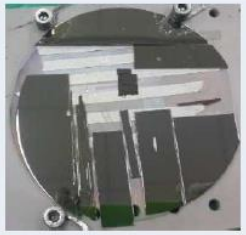
E : Young's modulus
v : Poisson's ratio,
F : film
S : substrate
R : Curvature
d_s : Thickness of Substrate
d_f : Thickness of Film

$$\sigma_f = \frac{E_s d_s^{\,2}}{6R(1-vs)d_f} \propto \frac{1}{R\,df}$$

- If internal stress (σ_f) ➔ constant
- **Increasing thickness (d_f ↑)**

$$d_f \uparrow \qquad R \downarrow$$

- **Decreasing Curvature (R ↓)**
-

Poor adhesion	Strong adhesion
film peel (박리)	**Substrate Destruction (기판 파손)**
	

- Stress가 강한 ta-C 막이 두꺼워지면, 동일한 stress라고 하더라고 막과 기판의 곡률반경은 더 작아지게 되고, 이로 인하여 기판과 막사이의 밀착력에 의한 다양한 문제가 발생함

Generation of Stress _ Change of Film & Substrate

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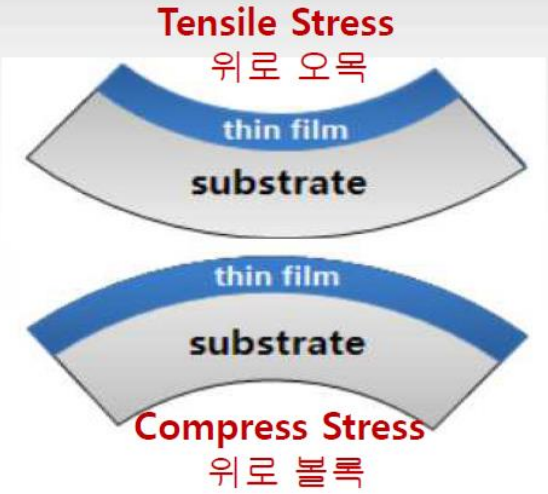
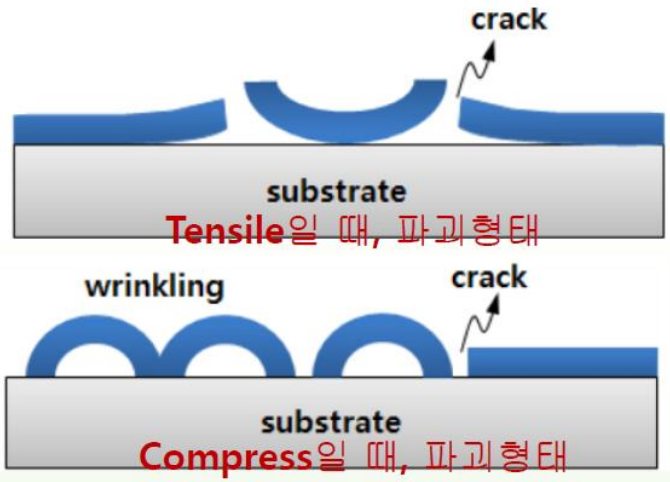
Film Effect

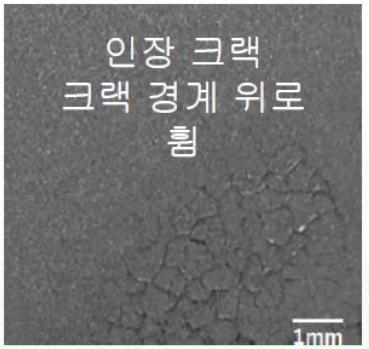
완성 이후

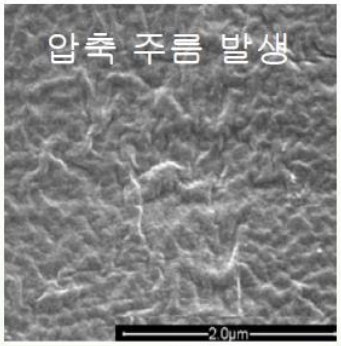


Substrate effect



완성 후 열변형으로 발생된 파괴거동





✓ 응력을 줄이기 위해서 두께는 물론, 재료의 교체, 박막의 미세조직제어 필요

✓ When Coating processes : control of Temperature, Pressure, Substrate bias, Removed dust and native Oxides

Stress ?

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Stress

- 인장 응력 (Tensile stress)

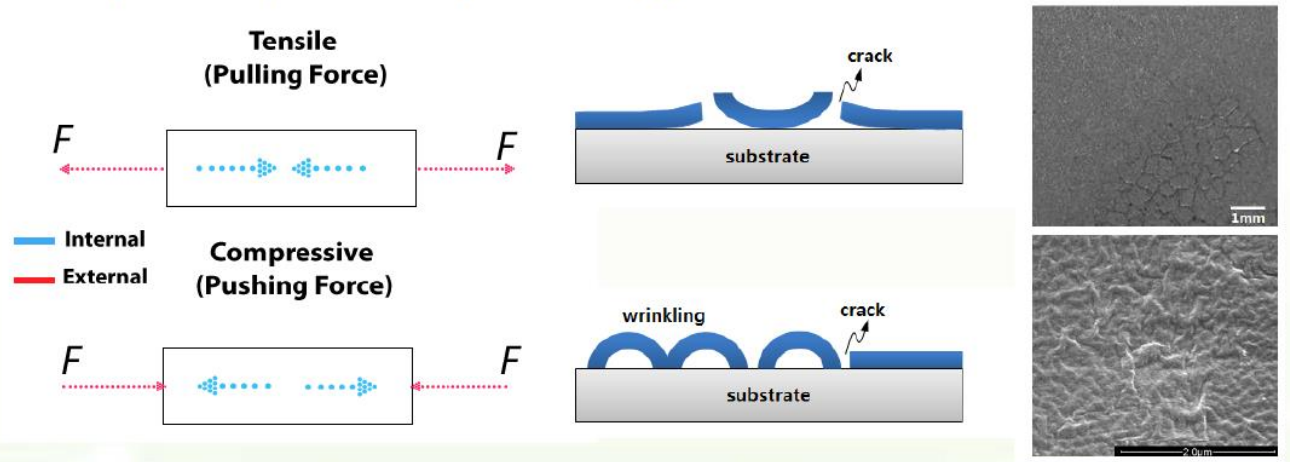
  : 박막 초기 수축 형태에서 박막 형성 후 수축 해소 위해 팽창하는 힘

  기판의 경우 반대로 압축으로 인한 박리 , ***Crazing(***미세실금) 발생

- 압축 응력 (Compressive stress)

  : 인장과 반대로 막이 수축하는 경우 기판의 경우 인장 발생

  힐록***(hillock)*** 및 주름***(wrinkling)*** 발생으로 인한 박리



Peeling : Thermal expansion, Film Thickness, Substrate Bias, Temperature, Pressure

박리의 원인 : (열팽창계수 차이, 박막의 두께, 기판 바이어스, 온도, 압력)