WAFER-SCALED SYNTHESIS OF 2D-MoS_2 BY COLD-WALL CVD

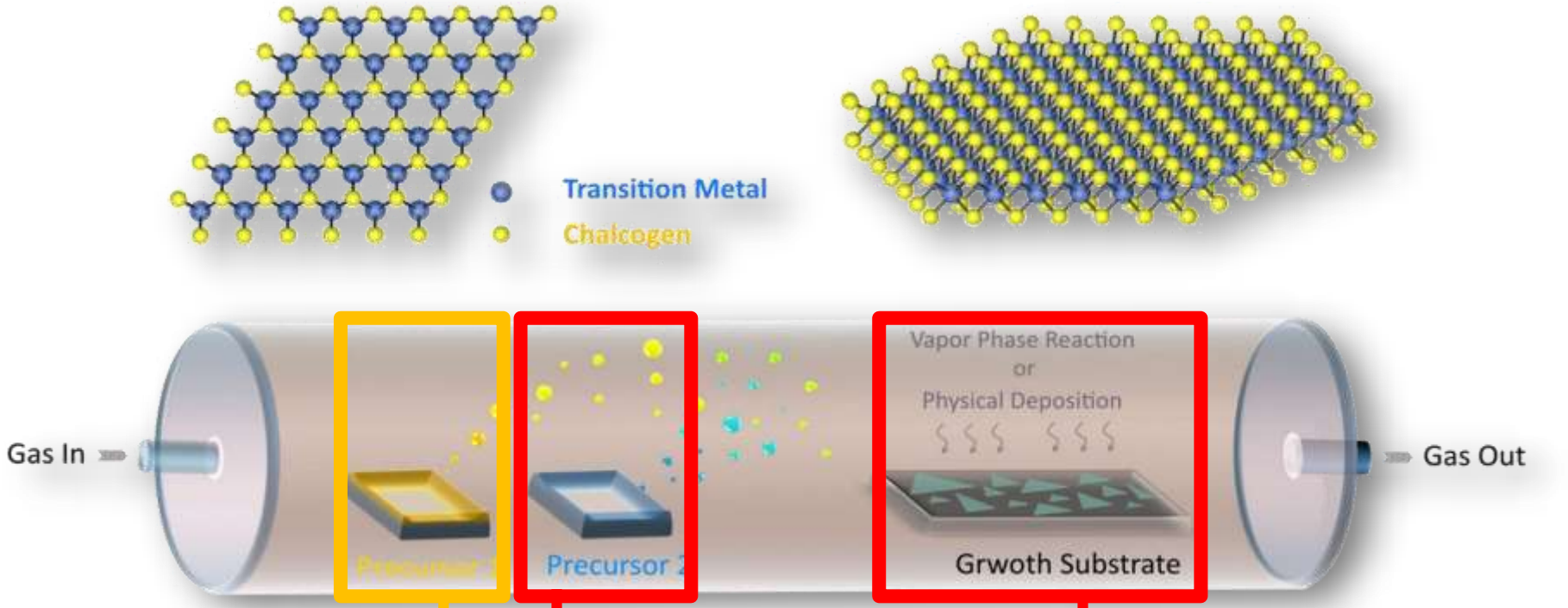
Dr. Zhen-Yu Juang, CTO
SulfurScience Technology Co. Ltd.

7th edition of the largest European Conference & Exhibition in Graphene and 2D Materials
Graphene 2017
March 28-31
Barcelona (Spain)

SulfurScience

Material	Process	Temp. (℃)	No. of layers	Ref.
MoS_2	MoO_3 and S powder with seeding	650	Monolayer	Lee et al. (2012); Ling et al. (2014)
MoS_2	MoO_3 and S powder	700	Monolayer	van der Zande et al. (2013)
MoS_2	MoO_3 nanoribbons and S powder	850	Monolayer	Najmaei et al. (2013)
MoS_2	MoO_3 and S powder	850	Monolayer	Ji et al. (2014)
MoS_2	MoO_3 and S powder	700	Monolayer	Dumcenco et al. (2015)
MoS_2	MoO_3 and H_2S gas	600	Monolayer	Kim et al. (2016)
MoS_2	MoO_3 and S powder	850	Mono-, bi- and trilayer	Jeon et al. (2015)
MoS_2, WS_2	$Mo(CO)_6$, $W(CO)_6$, and diethyl sulfide	550	Monolayer	Kang et al. (2015)
MoS_2–WS_2, $MoSe_2$–WSe_2	WO_3, MoO_3 and S powder	650 - 750	Monolayer	Zhang et al. (2015)

https://2dmaterials.kaust.edu.sa/Pages/Home.aspx#

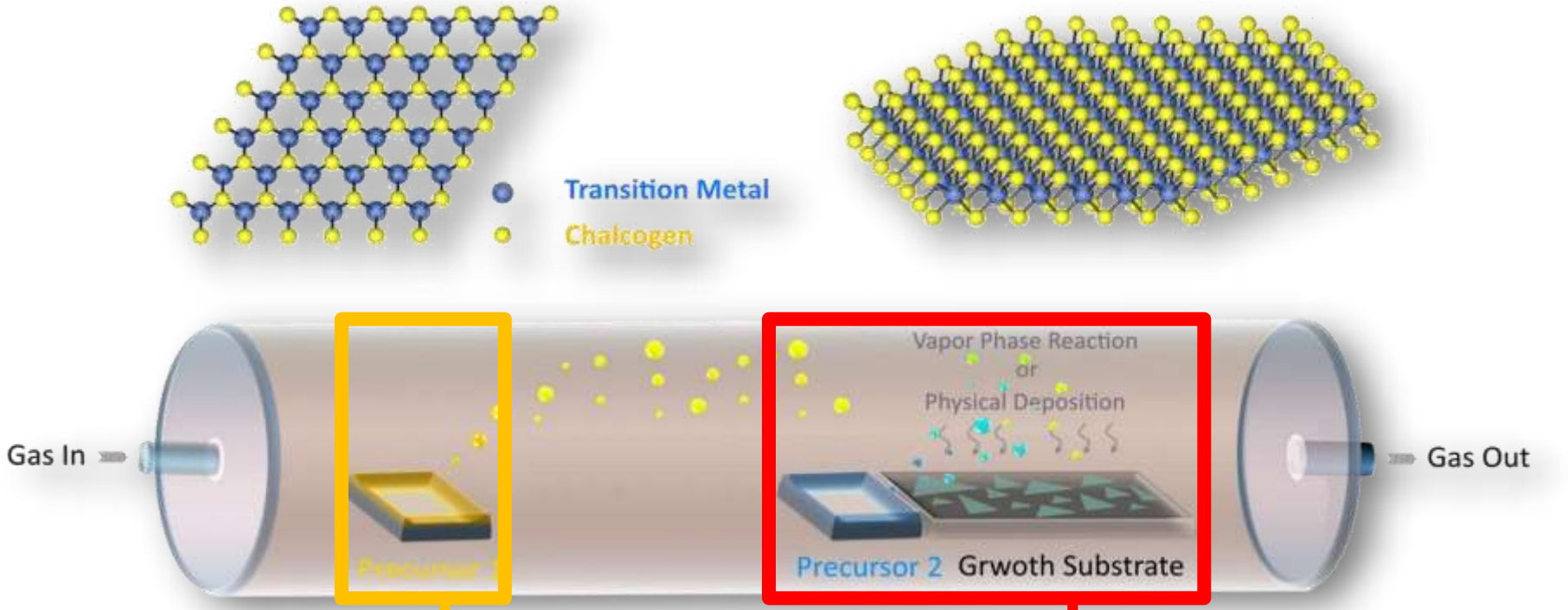


Low temperature zone for the precursor with low melting temperature

High temperature zone for the precursor with high melting temperature

High temperature zone for MoS_2 synthesis

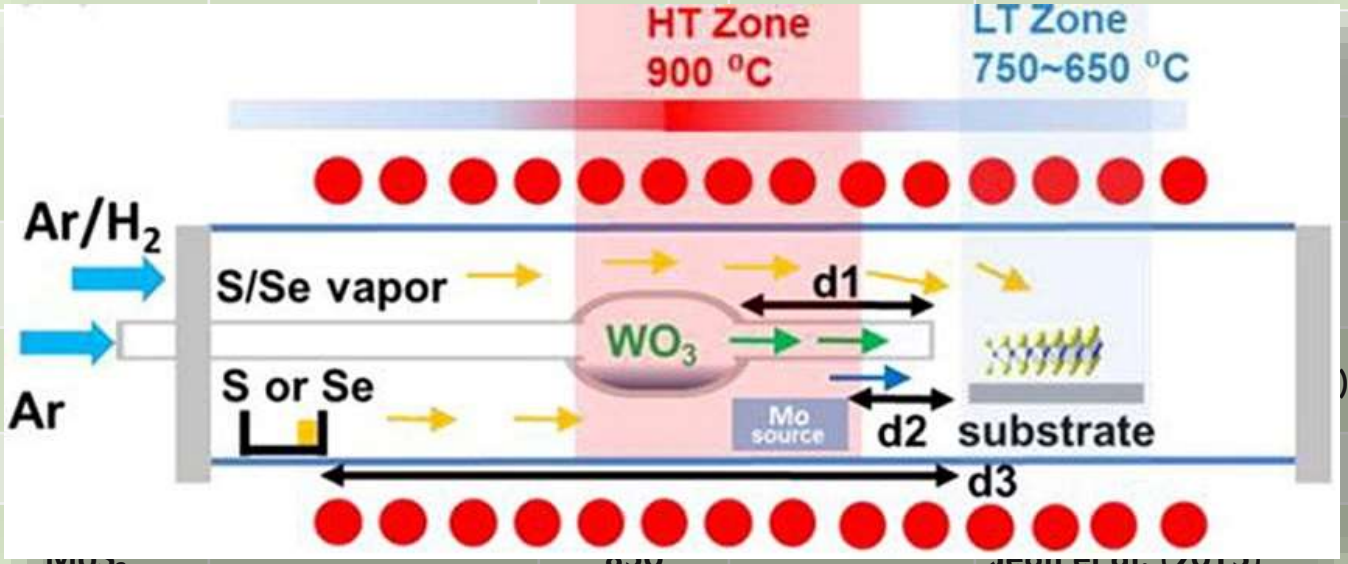
https://2dmaterials.kaust.edu.sa/Pages/Home.aspx#



Low temperature zone for the precursor with low melting temperature

High temperature zone for both high-MP precursor MoS_2 synthesis

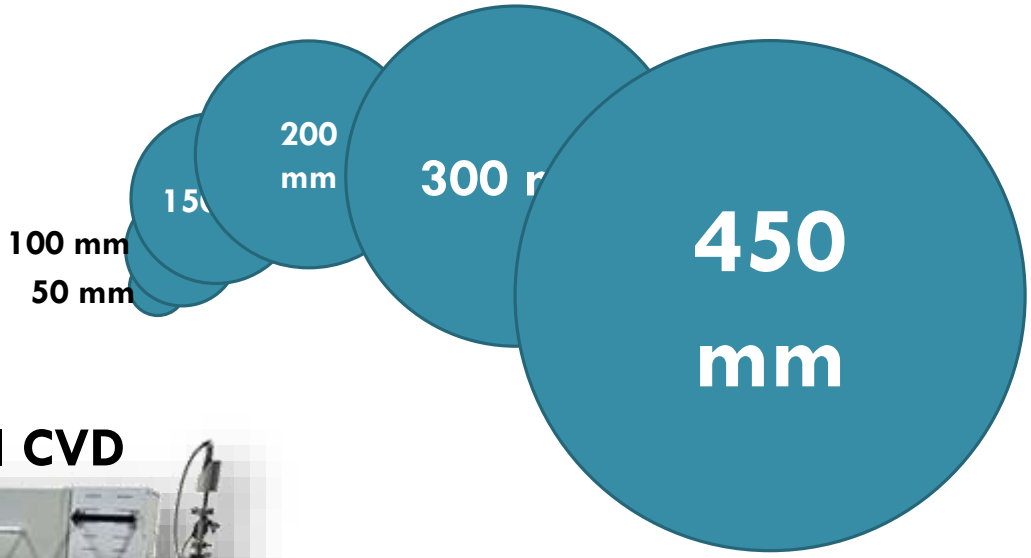
Material	Process	Temp. (℃)	No. of layers	Ref.
MoS_2	MoO_3 and S powder with seeding	650	Monolayer	Lee et al. (2012); Ling et al. (2014)
	powder		and trilayer	
MoS_2, WS_2	$Mo(CO)_6$, $W(CO)_6$, and diethyl sulfide	550	Monolayer	Kang et al. (2015)
MoS_2–WS_2, $MoSe_2$–WSe_2	WO_3, MoO_3 and S powder	650 - 750	Monolayer	Zhang et al. (2015)



- The temperatures for precursors and MoS_2 synthesis are commonly different.
- The m.p. of metal oxide precursors are normally higher than that of MoS_2 synthesis .

- **Individually control the temperature of different heating zones are necessary.**

PROCESS SCALE-UP



Hot-wall CVD

Wafer size for HW-CVD is limited!

Size does matter…

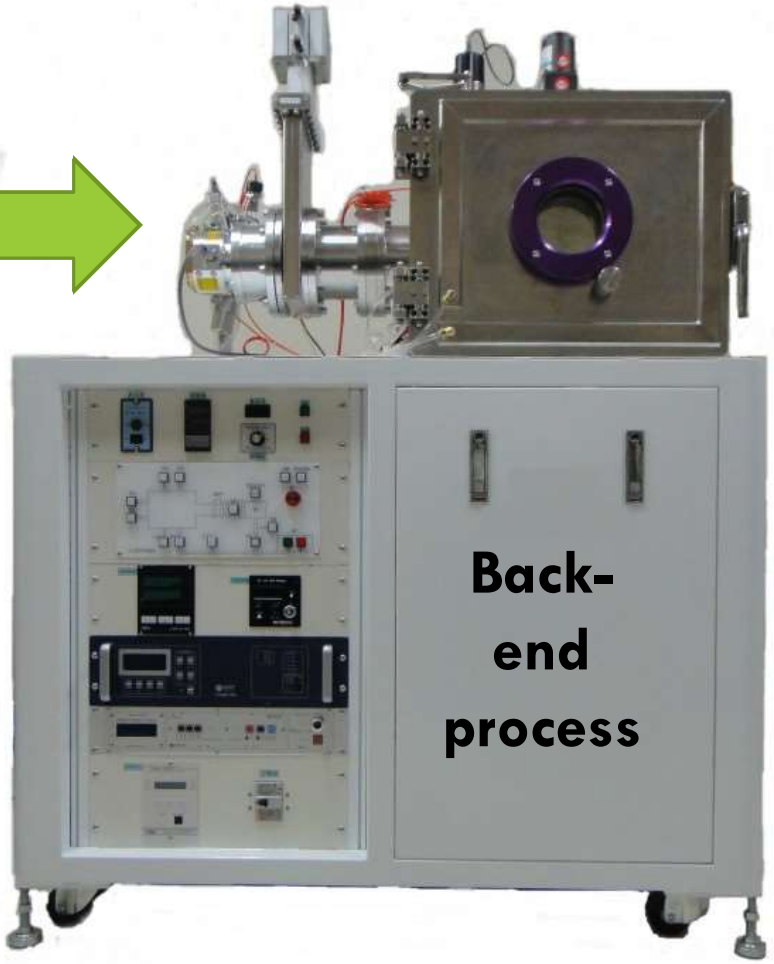
http://funny-hamster.blogspot.tw/2016/01/can-hamster-eat-carrots.html

PROCESS CAOMPABILITY

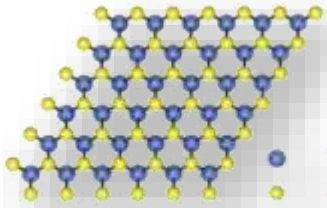
?

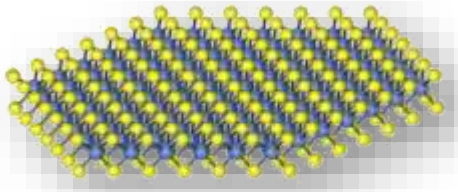
Hot-wall CVD

Load-lock chamber



Back-end process

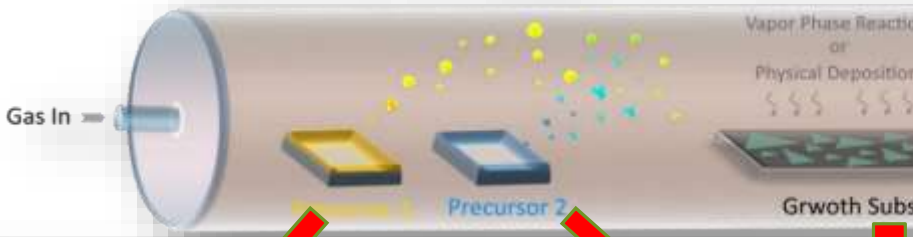


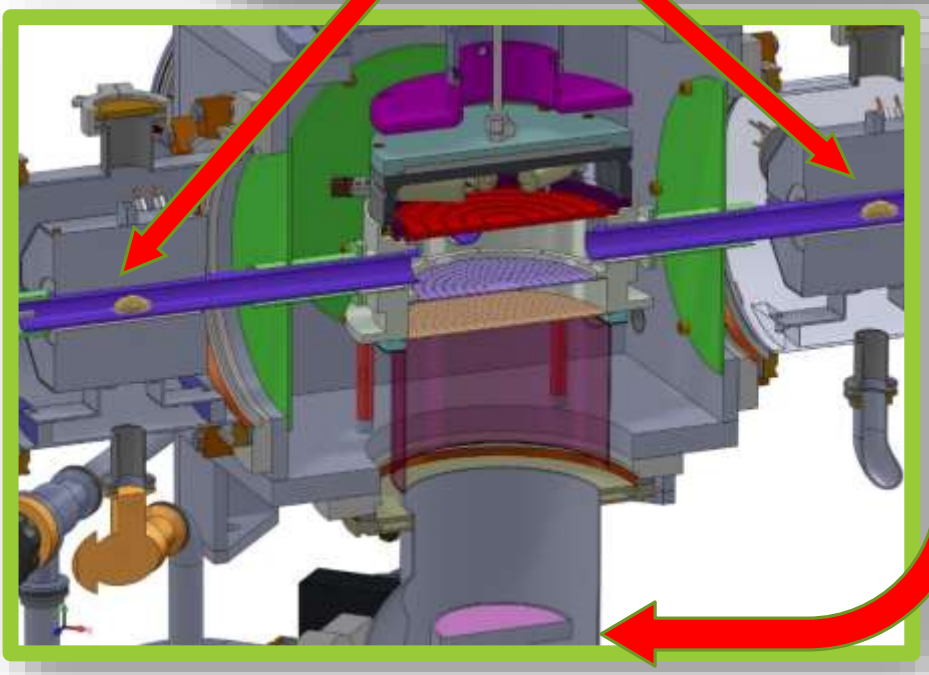


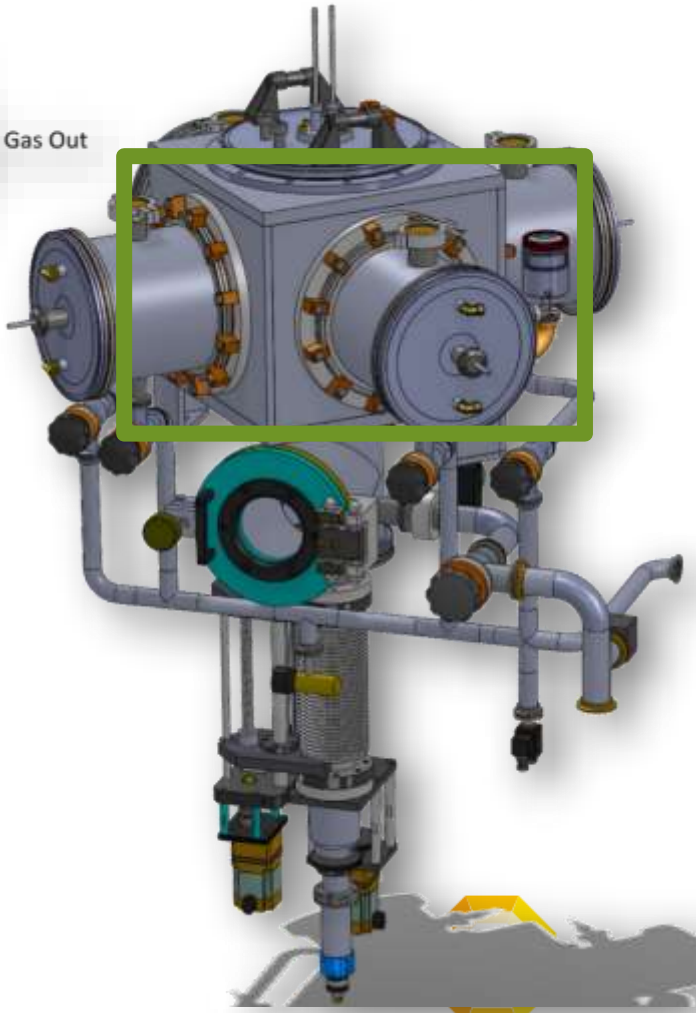
Transition Metal

Chalcogen

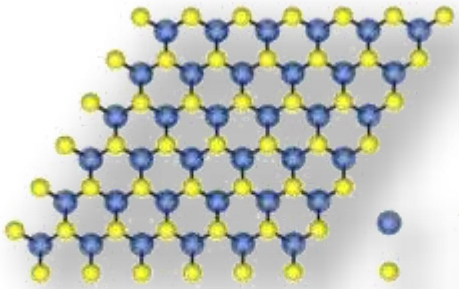
Cold-wall CVD





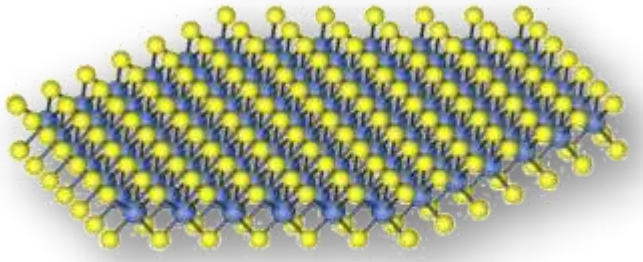


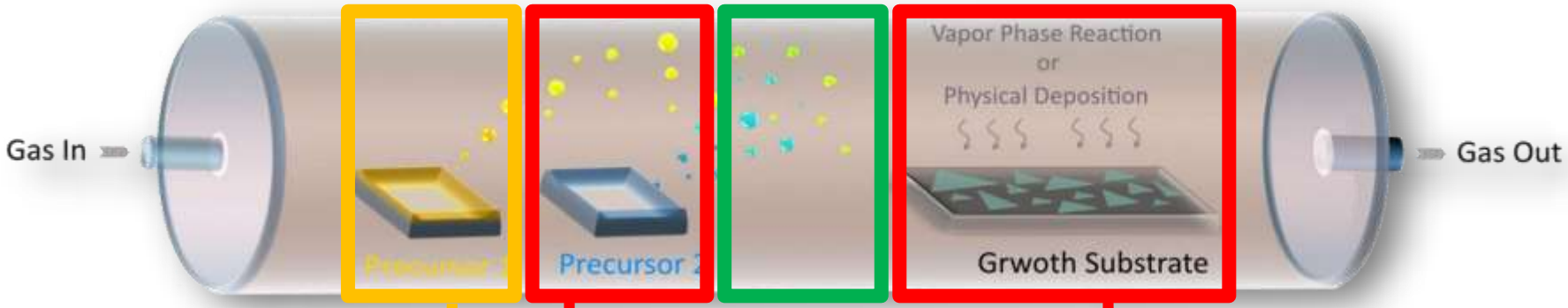
https://2dmaterials.kaust.edu.sa/Pages/Home.aspx#



Transition Metal

Chalcogen

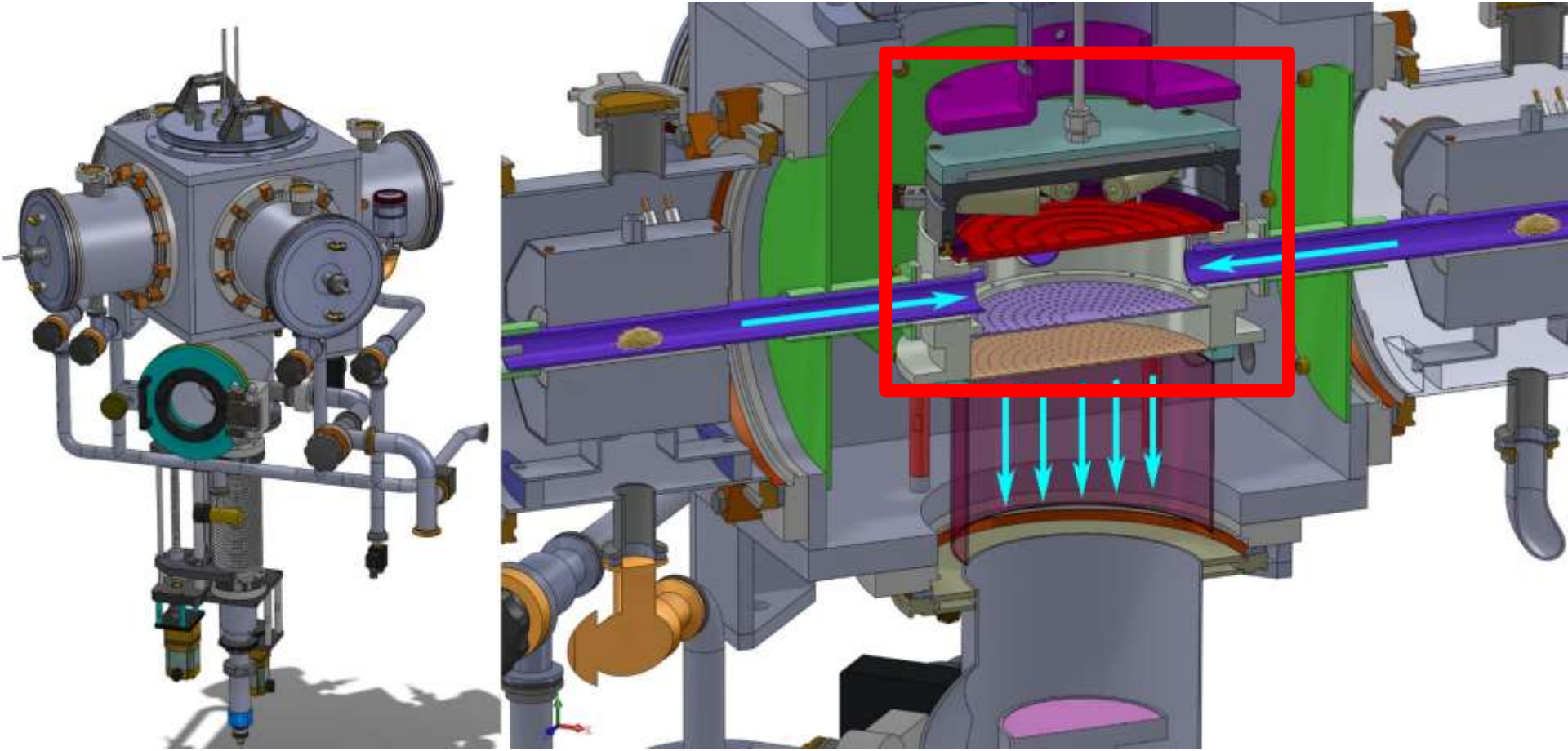




Low temperature zone for the precursor with low melting temperature

High temperature zone for the precursor with high melting temperature

High temperature zone for MoS_2 synthesis



SUMMARY

Disadvantages of HW-CVD

- **Difficulty of temperature control**
- **Difficulty of scaled-up**
- **Less of compatibility**

Cold-wall CVD

Hot-wall CVD

CW-CVD allows

- **Precisely control the temperatures of separated heating zones**
- **Large wafer available**
- **Flexibility and compatibility to industry specifications**

ACKNOWLEDGEMENT

Prof. Lain-Jong Li

Prof. Wen-Hao Chang

Dr. Ming-Yang Li

Dr. Yung-Huang Chang

Dr. Chia-Chin Cheng

SulfurScience

Booth 13 & Poster 298

Li-Syuan Lu

Chun-Yi Kuo

Thanks for your attentions

7th edition of the largest European Conference & Exhibition in Graphene and 2D Materials

Graphene 2017 March 28-31 Barcelona (Spain)

Sulfur Science