Supplementary Information

Inverted vortex fluidic exfoliation and scrolling of hexagonal-boron nitride

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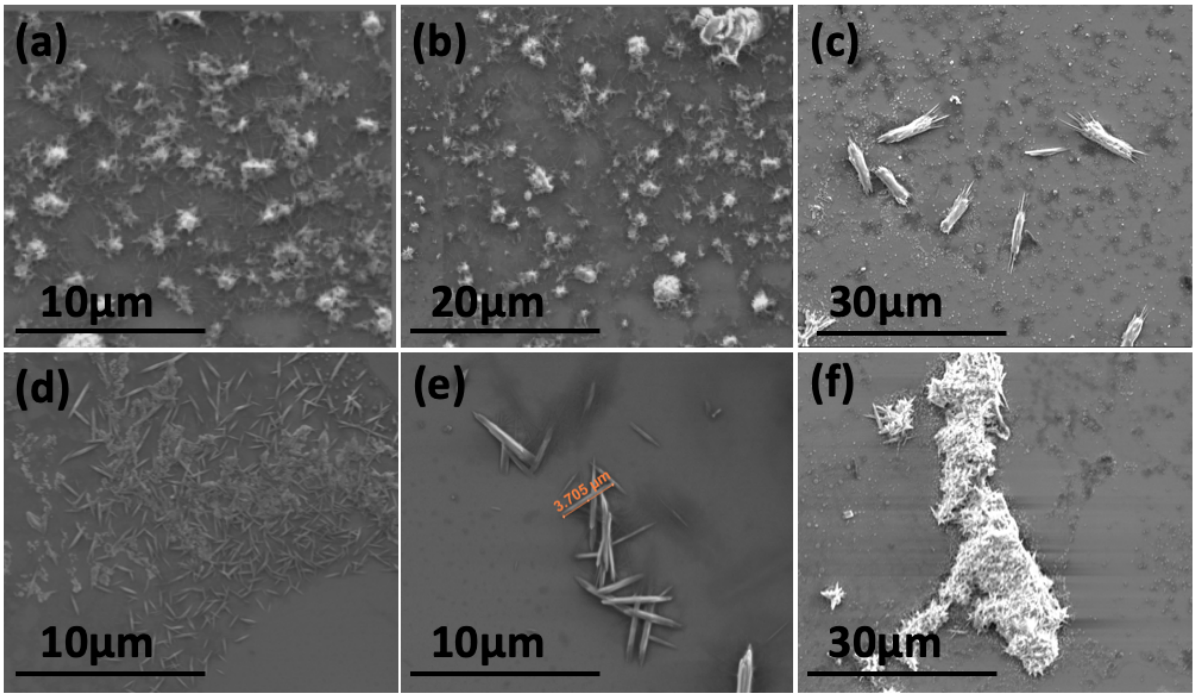

Fig. S1. SEM images: (a) As received *h*-BN. (b-f) Drop-cast *h*-BN scrolls on silicon wafer of the supernatant after centrifuging at RCF = 1180 g, post VFD processing at 6k rpm rotational speed, tilt angle -45º, flow rate 0.3 mL/min, and concentration 0.1 mg/mL.

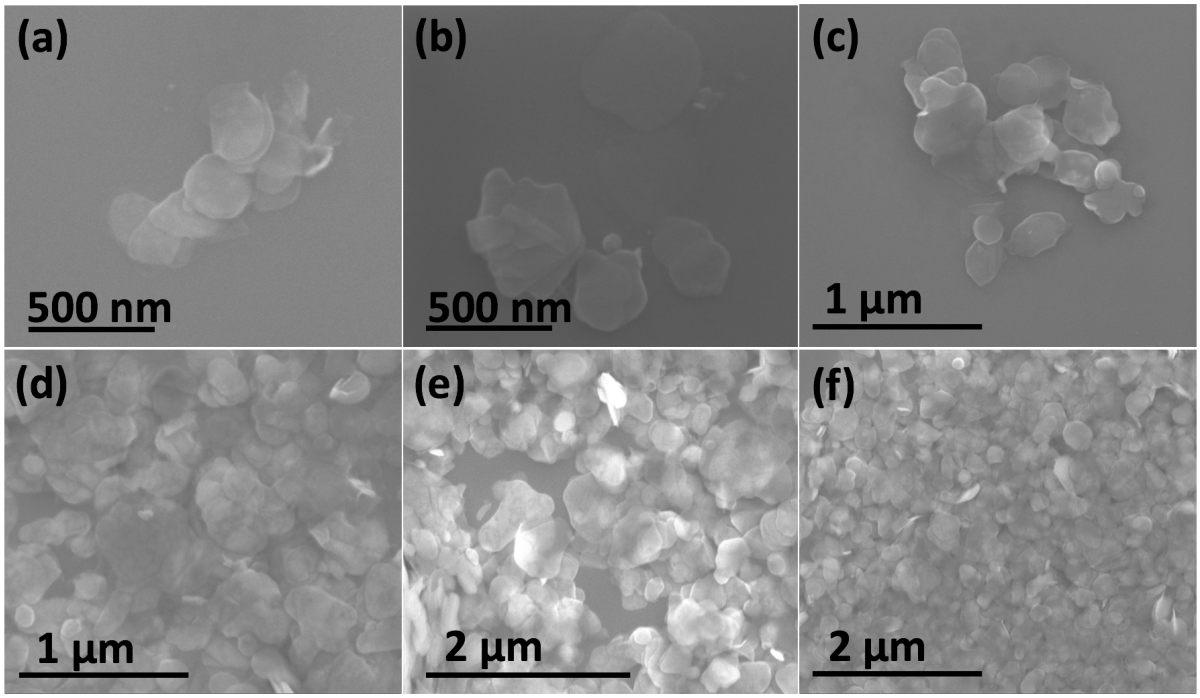

Fig. S2. (a-f) SEM images of exfoliated *h*-BN drop cast on silicon wafer using the supernatant after centrifuging at RCF = 1180 g for 3 min, post VFD processing, rotational speed 6k rpm, tilt angle -45º, flow rate 0.75 mL/min, concentration 0.3 mg/mL.

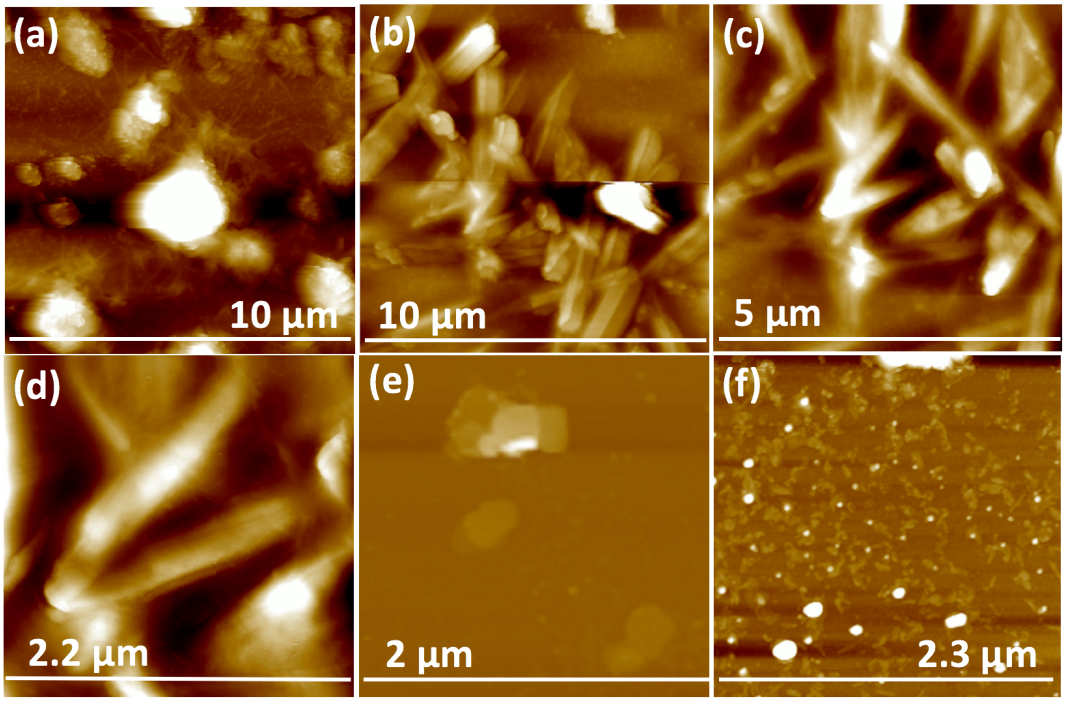

Fig. S3. AFM images of drop cast *h*-BN scrolls on silicon wafer using the supernatant after centrifuging at RCF = 1180 g, post VFD processing (rotational speed 6k rpm, tilt angle -45º), (a-d) *h*-BN scrolls prepared using a flow rate of 0.3 mL/min and concentration 0.1 mg/mL. (e-f) Exfoliated *h*-BN prepared using a flow rate of 0.75 mL/min, concentration 0.3 mg/mL.

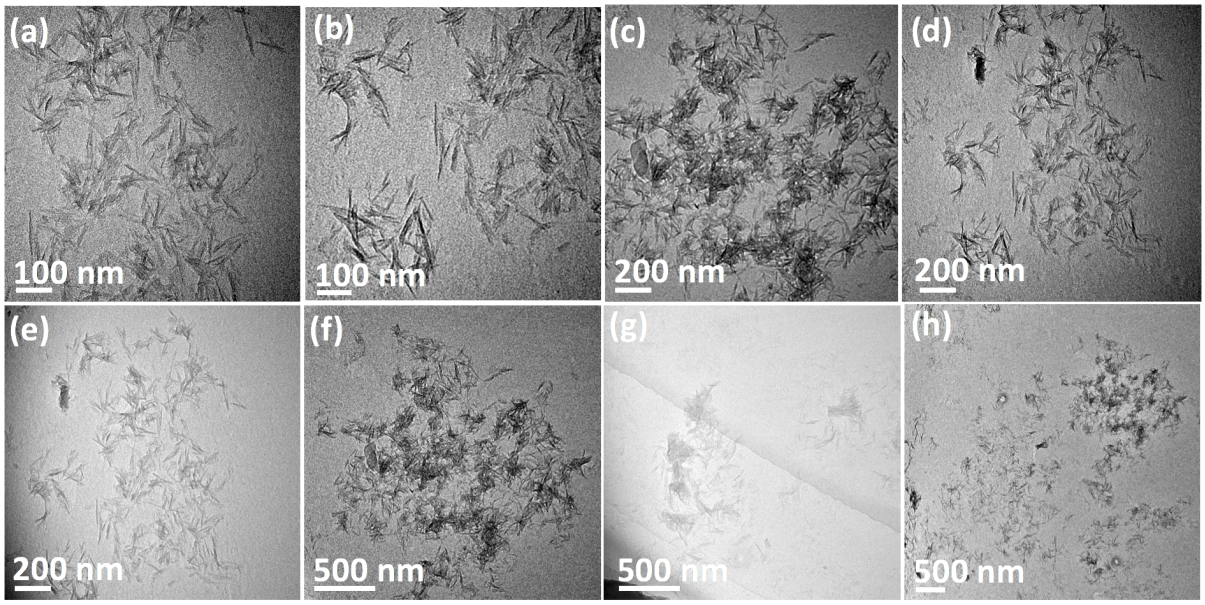

Fig. S4. TEM images of drop cast *h*-BN scrolls on a grid, post VFD processing at 6k rpm rotational speed, tilt angle -45º, flow rate 0.3 mL/min and concentration 0.1 mg/mL.

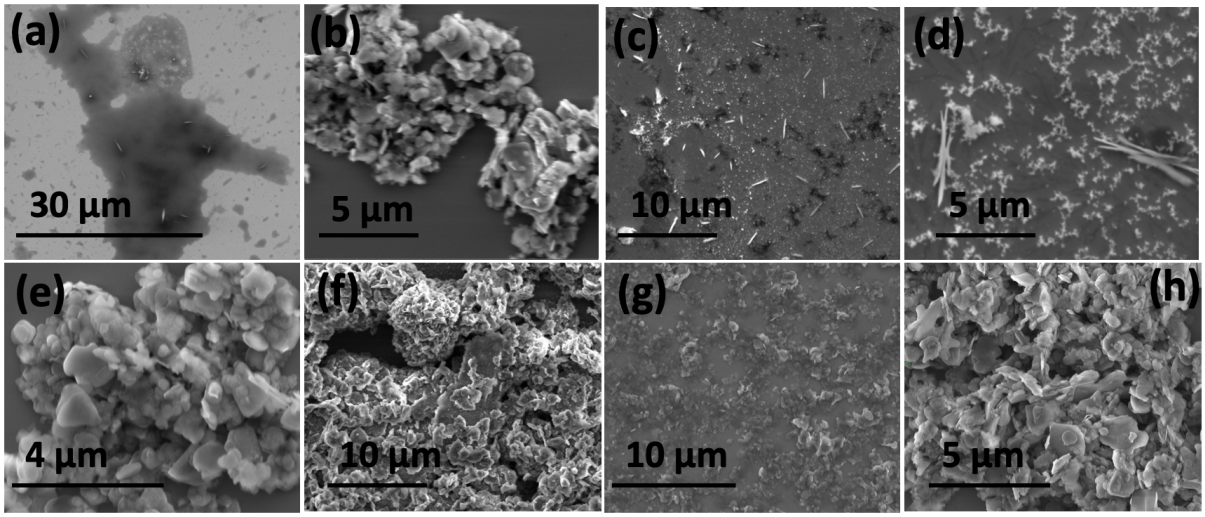

Fig. S5 SEM images for *h*-BN in water, post VFD processing at a concentration of 0.1 mg/ mL, rotational speed 6k rpm and flow rate of the *h*-BN in water at 0.3 mL/min, for different tilt angles. (a, b) +45º. (c, d) +20º. (e, f) 0º. (g, h) -20º.

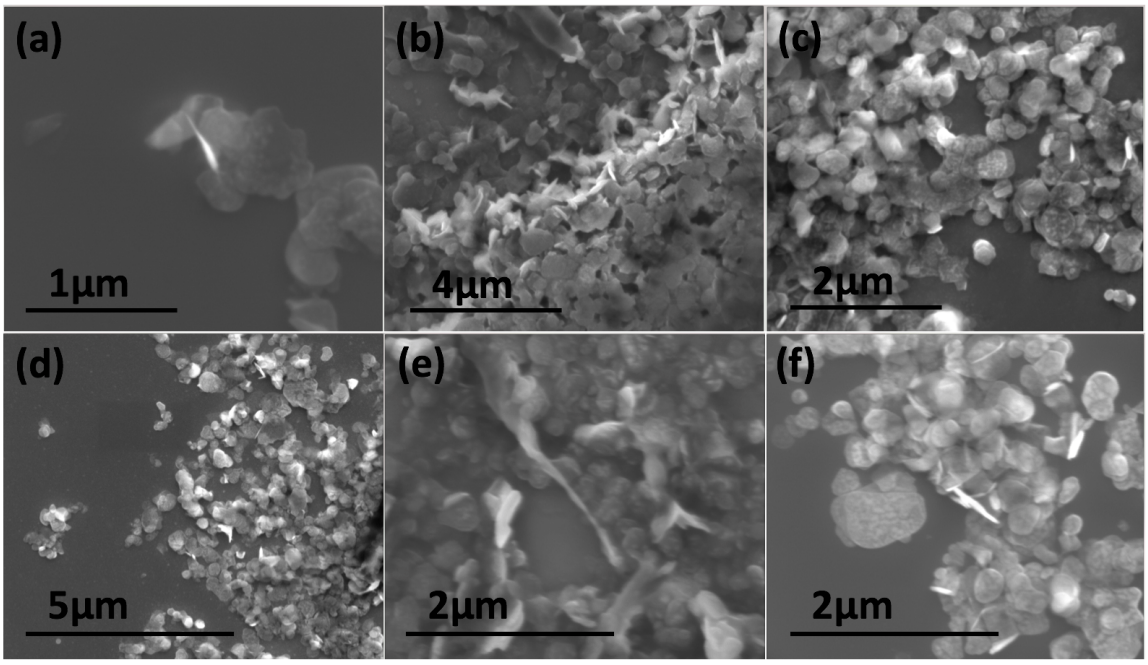

Fig. S6. The exfoliation product of *h*-BN after VFD processing to form scrolls, with the initial concentration 0.1 mg/mL, tilt angle +45^{o} using the confined mode for different rotational speeds. (a-b) 2k rpm for 30 min. (c-d) 3.5k rpm for 10 min. (e-f) 5.5 rpm for 10 min.

Table S1. VFD optimisation experiments. Operating parameters of the VFD were varied based on the mode of reaction, rotational speed of the tube, tilt angle, flow rate of the reactants, single solvent systems and mixed solvent systems.

	Solvent	**Mode**	**Speed**	**Concentration**	**Angel**	**Flow rate**	**Other**	**Formation of scrolls or exfoliation**
1.	NMP only	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	5, 10, 30 min and 1 h	No
2.	NMP+ water (1:1)	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	10 and 30 min	No
3.	NMP+ water (1:1)	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
4.	NMP+ water (1:1)	continuous	7500rpm	0.1 mg/mL	+20˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
5.	Isopropanol	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	5, 10, 30 min and 1 h	No
6.	Isopropanol + water (1:1)	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	5, 10, 30 min and 1 h	No
7.	Isopropanol + water (1:1)	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
8.	Isopropanol + water (1:1)	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	-20˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
9.	Isopropanol + water (1:1)	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	-45˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min	Laser 260 mJ and 600 mJ	No
10.	Toluene	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	5, 10, 30 min and 1 h	No
11.	Toluene	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
12.	Toluene +water (1:1)	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	5, 10, 30 min and 1 h	No
13.	Toluene + water (1:1)	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
14.	Toluene + water (1:1)	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+20˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
15.	Toluene + water (1:1)	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	0 ˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No

16.	Water	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	5, 10, 30 min and 1 h	No
17.	Water	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	Laser 260 mJ and 600 mJ	No
18.	Water with $FeCl_3$	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	N/A	30 min	No
19.	Water	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+45˚	0.1, 0.5, 0.75 and 1 mL/min		No
20.	Water	continuous	6k rpm	0.1 mg/mL	+45˚	0.3 mL/min	Heating unite 70C	No
21.	Water	continuous	7.5k rpm	0.1 mg/mL	+20˚	0.3 mL/min	Heating unite 70C	No
22.	Water	continuous	7.5 rpm	0.1 mg/mL	+45˚	0.3 mL/min	Laser 260mJ and 600 mJ	No
23.	Water	confined	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	+20˚	N/A	5, 10, 30 min and 1 h	No
24.	Water	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	0º	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
25.	Water	continuous	4k, 5k, 6k, 7k and 8k rpm	0.2 mg/mL	0º	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
26.	Water	continuous	4k, 5k, 6k, 7k and 8k rpm	0.1 mg/mL	-20˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min		No
27.	Water	continuous	4k, 5k, 7k and 8k rpm	0.1 mg/mL	-45˚	0.1, 0.5, 0.75 and 1 mL/min		No
28.	**Water**	**continuous**	**6k rpm**	**0.1 mg/mL**	**-45˚**	**0.3 mL/min**		**Scrolls**
29.	Water	continuous	6k rpm	0.1 mg/mL	-45˚	0.3 mL/min	Recycle twice	No
30.	Water	continuous	6k rpm	1 mg/mL	-45˚	0.3 mL/min	Recycle twice	No
31.	Water	continuous	6k rpm	1 mg/mL	-45˚	0.3 mL/min	Recycle three times	No
32.	Water	continuous	7.5k rpm	0.1 mg/mL	+45˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min	10 mm of VFD tube	No
33.	Water	continuous	7.5k rpm	0.1 mg/mL	+20˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min	10 mm of VFD tube	No
34.	Water	continuous	7.5k rpm	0.1 mg/mL	0˚	0.1, 0.3, 0.5, 0.75 and 1 mL/min	10 mm of VFD tube	No
35.	Water 1 M of HCl	continuous	6k rpm	0.1 mg/mL	-45˚	0.3 mL/min		No

36.	Water 1 M of NaOH	continuous	6k rpm	0.1 mg/mL	-45˚	0.3 mL/min		No
37.	Water	continuous	4k, 5k, 7k and 8k rpm	0.3 mg/mL	-45˚	0.3, 0.5 and 1 mL/min		No
38.	**Water**	**continuous**	**6k rpm**	**0.3 mg/mL**	**-45˚**	**0.75 mL/min**		**Exfoliation**
39.	Water	continuous	4k, 5k, 6k, 7k and 8k rpm	0.5 mg/mL	-45˚	0.3, 0.5, 0.75 and 1 mL/min		No
40.	Water	continuous	4k, 5k, 6k, 7k and 8k rpm	0.7 mg/mL	-45˚	0.3, 0.5, 0.75 and 1 mL/min		No
41.	Water	continuous	4k, 5k, 6k, 7k and 8k rpm	1 mg/mL	-45˚	0.3, 0.5, 0.75 and 1 mL/min		No