Electronic Supplementary Information

Introducing antiferromagnetic ordering on the surface states of Bi_2Se_3 topological insulator by Europium doping

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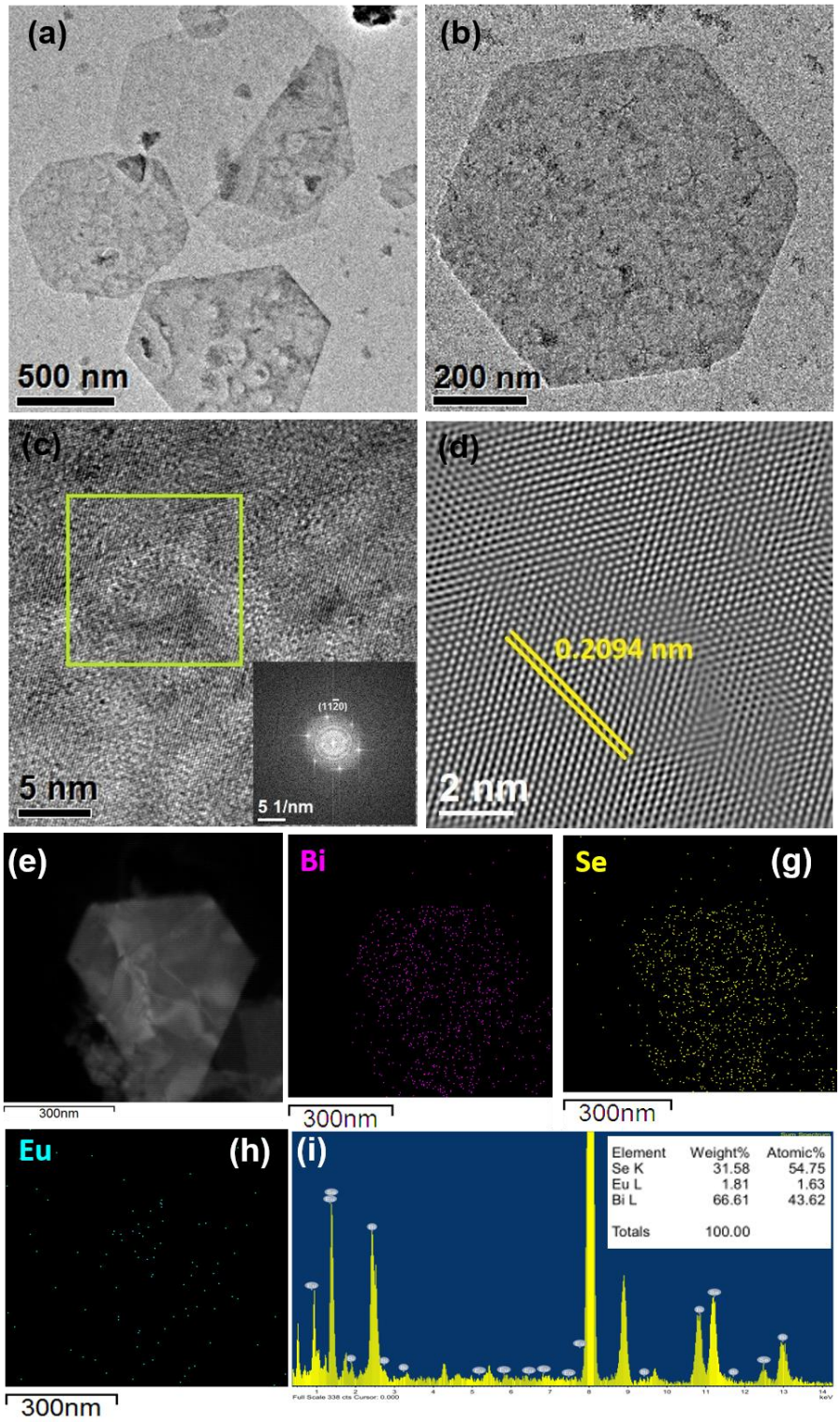

Figure S1. (a) Large area inverted TEM image of undoped 5% Eu doped Bi_2Se_3 NSs. (b) A closer view of a single microsheet. (c) HRTEM lattice image of a single MS; the inset shows the FFT pattern of the (11-20) group of planes as obtained from the yellow squared region of HRTEM image of Bi_2Se_3. (d) Reconstructed HRTEM image showing the *d* spacing value of 0.209 nm corresponding to the group of planes (11-20). (e) Scanning TEM image of Bi_2Se_3 nanosheet and corresponding STEM elemental mapping of (f) Bi, (g) Se and (h) Eu atoms, respectively. (i) Energy dispersive X-ray (EDX) spectrum of Bi_2Se_3 MS showing the atomic percentage of different elements.

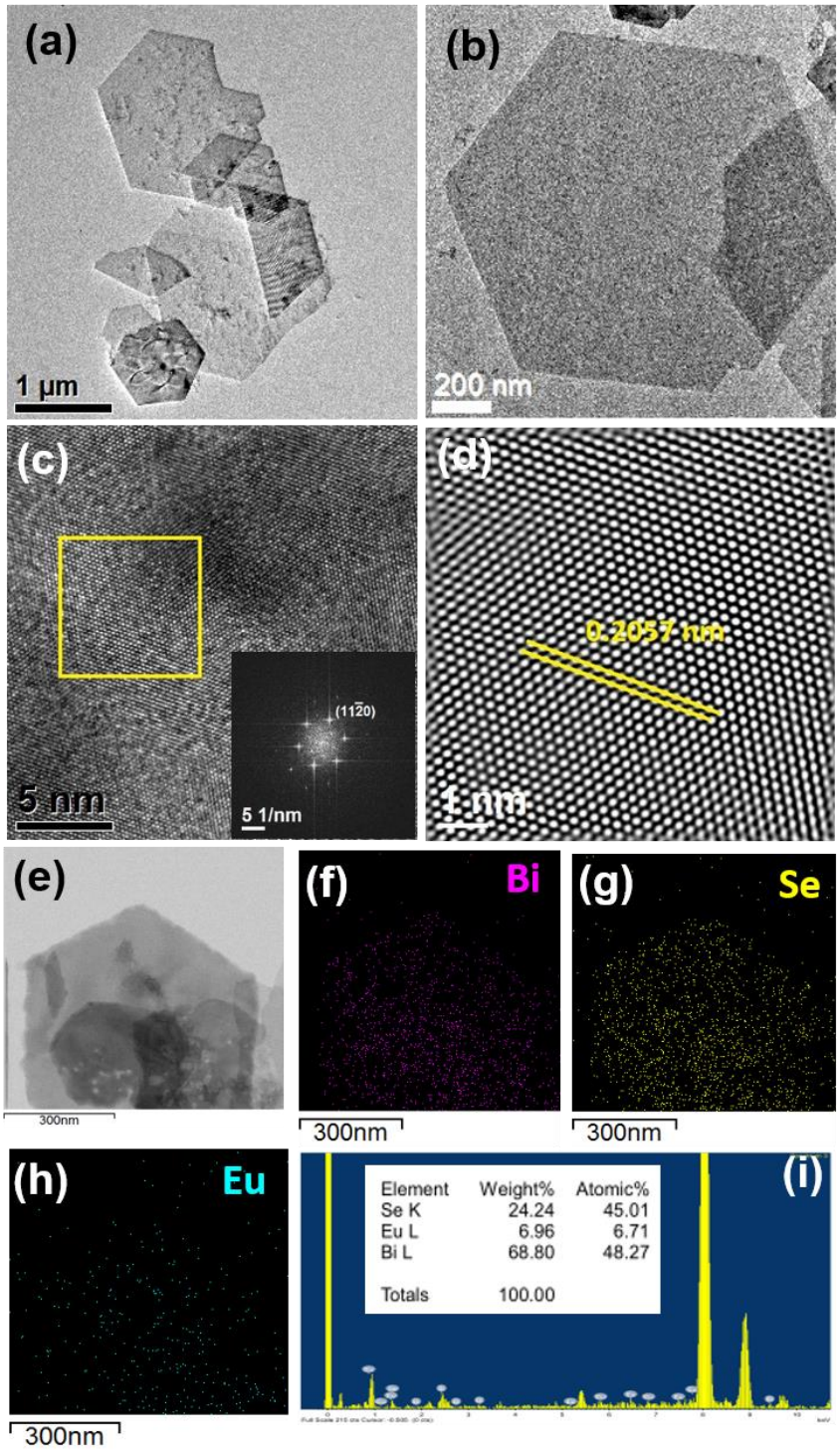

Figure S2. (a) Large area inverted TEM image of undoped 10% Eu doped Bi_2Se_3 NSs. (b) A closer view of a single microsheet. (c) HRTEM lattice image of a single MS; the inset shows the FFT pattern of the (11-20) group of planes as obtained from the yellow squared region of HRTEM image of Bi_2Se_3. (d) Reconstructed HRTEM image showing the *d* spacing value of 0.205 nm corresponding to the group of planes (11-20). (e) Scanning TEM image of Bi_2Se_3 nanosheet and corresponding STEM elemental mapping of (f) Bi, (g) Se and (h) Eu atoms, respectively. (i) Energy dispersive X-ray (EDX) spectrum of Bi_2Se_3 MS showing the atomic percentage of different elements.

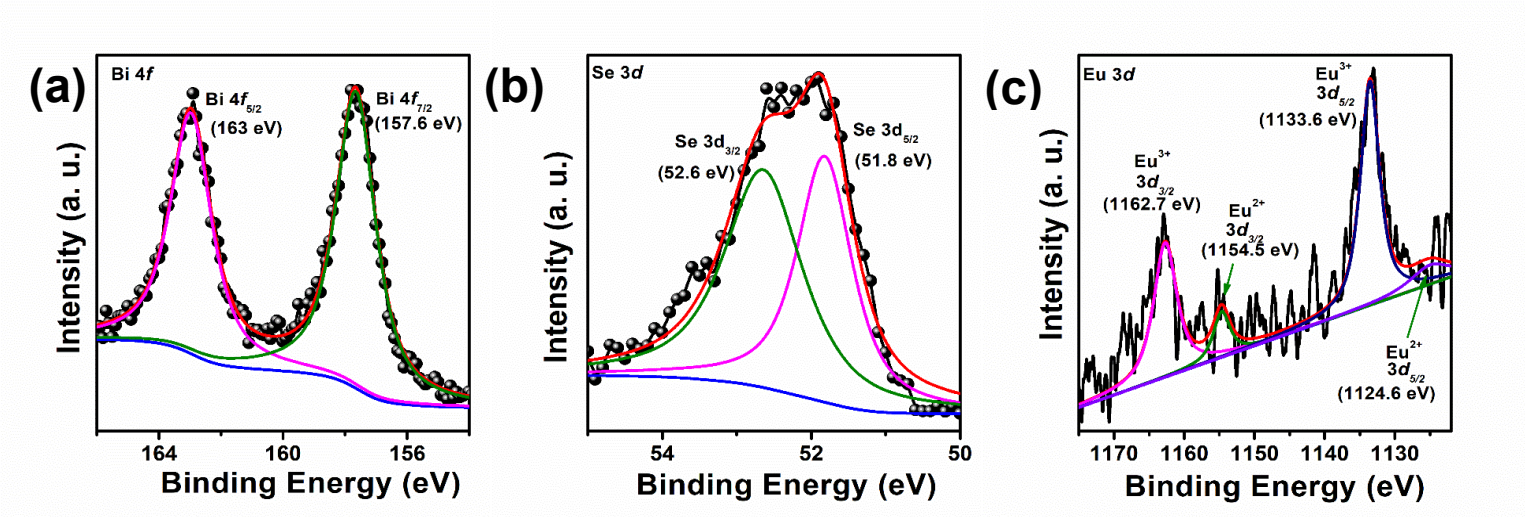

Figure S3. Lorentzian fitted XPSspectrumof the elements:(a) Bi 4f core-level,(b) Se 3d core-level,(c) Eu 3d core-level. The solid lines refer to the fitted peaks with a Shirley baseline,and the symbols correspond to the experimental data.

Bi2Se3

data_Bi2Se3

_audit_creation_method

_cell_length_a 4.1888195996

_cell_length_b 4.1888195996

_cell_length_c 30.8113039972

_cell_angle_alpha 90.0000000000

_cell_angle_beta 90.0000000000

_cell_angle_gamma 120.0000000000

_cell_volume 468.1920387017

_symmetry_space_group_name_H-M "R -3 2/m (hexagonal axes)"

_symmetry_Int_Tables_number 166

_space_group.reference_setting '166:-R 3 2'"

_space_group.transform_Pp_abc a,b,c;0,0,0

loop_

_space_group_symop_id

_space_group_symop_operation_xyz

1 x,y,z

2 -y,x-y,z

3 -x+y,-x,z

4 y,x,-z

5 -x,-x+y,-z

6 x-y,-y,-z

7 -x,-y,-z

8 y,-x+y,-z

9 x-y,x,-z

10 -y,-x,z

11 x,x-y,z

12 -x+y,y,z

13 x+1/3,y+2/3,z+2/3

14 -y+1/3,x-y+2/3,z+2/3

15 -x+y+1/3,-x+2/3,z+2/3

16 y+1/3,x+2/3,-z+2/3

17 -x+1/3,-x+y+2/3,-z+2/3

18 x-y+1/3,-y+2/3,-z+2/3

19 -x+1/3,-y+2/3,-z+2/3

20 y+1/3,-x+y+2/3,-z+2/3

21 x-y+1/3,x+2/3,-z+2/3

22 -y+1/3,-x+2/3,z+2/3

23 x+1/3,x-y+2/3,z+2/3

24 -x+y+1/3,y+2/3,z+2/3

25 x+2/3,y+1/3,z+1/3

26 -y+2/3,x-y+1/3,z+1/3

27 -x+y+2/3,-x+1/3,z+1/3

28 y+2/3,x+1/3,-z+1/3

29 -x+2/3,-x+y+1/3,-z+1/3

30 x-y+2/3,-y+1/3,-z+1/3

31 -x+2/3,-y+1/3,-z+1/3

32 y+2/3,-x+y+1/3,-z+1/3

33 x-y+2/3,x+1/3,-z+1/3

34 -y+2/3,-x+1/3,z+1/3

35 x+2/3,x-y+1/3,z+1/3

36 -x+y+2/3,y+1/3,z+1/3

```
loop_
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_atom_site_type_symbol
_atom_site_symmetry_multiplicity
_atom_site_Wyckoff_symbol
_atom_site_fract_x
_atom_site_fract_y
_atom_site_fract_z
_atom_site_occupancy
_atom_site_fract_symmform
Bi1 Bi   6 c  0.00000  0.00000  0.39658  1.00000 0,0,Dz
Se1 Se   3 a  0.00000  0.00000  0.00000  1.00000 0,0,0
Se2 Se   6 c  0.00000  0.00000  0.78071  1.00000 0,0,Dz

# end of cif
```

```
#======================================================================
# CRYSTAL DATA
#----------------------------------------------------------------------
data_Bi15Eu1Se24

_chemical_name_common                  'Bi15Eu1Se24'
_cell_length_a                         21.177450
_cell_length_b                         21.177450
_cell_length_c                         21.177450
_cell_angle_alpha                      22.840445
_cell_angle_beta                       22.840445
_cell_angle_gamma                      22.840445
_cell_volume                           1255.734964
_space_group_name_H-M_alt              'P 1'
_space_group_IT_number                 1

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   'x, y, z'

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   _atom_site_fract_x
   _atom_site_fract_y
   _atom_site_fract_z
   _atom_site_adp_type
   _atom_site_U_iso_or_equiv
   _atom_site_type_symbol
   Bi1      1.0    0.197266    0.201268    0.197266    Uiso  ? Bi
   Bi2      1.0    0.198225    0.198050    0.698050    Uiso  ? Bi
   Bi3      1.0    0.198132    0.698132    0.198132    Uiso  ? Bi
   Bi4      1.0    0.197266    0.697266    0.701268    Uiso  ? Bi
   Bi5      1.0    0.698050    0.198050    0.198225    Uiso  ? Bi
   Bi6      1.0    0.701268    0.697266    0.197266    Uiso  ? Bi
```

Bi7	1.0	0.698050	0.698225	0.698050	Uiso	?	Bi
Bi8	1.0	0.301894	0.302291	0.301894	Uiso	?	Bi
Bi9	1.0	0.303171	0.301573	0.801573	Uiso	?	Bi
Bi10	1.0	0.301067	0.801067	0.301067	Uiso	?	Bi
Bi11	1.0	0.301894	0.801894	0.802291	Uiso	?	Bi
Bi12	1.0	0.801573	0.301573	0.303171	Uiso	?	Bi
Bi13	1.0	0.802030	0.302030	0.802030	Uiso	?	Bi
Bi14	1.0	0.802291	0.801894	0.301894	Uiso	?	Bi
Bi15	1.0	0.801573	0.803171	0.801573	Uiso	?	Bi
Eu1	1.0	0.696117	0.196117	0.696117	Uiso	?	Eu
Se1	1.0	0.000043	0.000301	0.000043	Uiso	?	Se
Se2	1.0	0.992021	0.004437	0.504437	Uiso	?	Se
Se3	1.0	0.999865	0.499865	0.999865	Uiso	?	Se
Se4	1.0	0.000043	0.500043	0.500301	Uiso	?	Se
Se5	1.0	0.504437	0.004437	0.992021	Uiso	?	Se
Se6	1.0	0.500173	0.000173	0.500173	Uiso	?	Se
Se7	1.0	0.500301	0.500043	0.000043	Uiso	?	Se
Se8	1.0	0.504437	0.492021	0.504437	Uiso	?	Se
Se9	1.0	0.389949	0.390114	0.389949	Uiso	?	Se
Se10	1.0	0.391199	0.388077	0.888077	Uiso	?	Se
Se11	1.0	0.390141	0.890141	0.390141	Uiso	?	Se
Se12	1.0	0.389949	0.889949	0.890114	Uiso	?	Se
Se13	1.0	0.888077	0.388077	0.391199	Uiso	?	Se
Se14	1.0	0.889985	0.389985	0.889985	Uiso	?	Se
Se15	1.0	0.890114	0.889949	0.389949	Uiso	?	Se
Se16	1.0	0.888077	0.891199	0.888077	Uiso	?	Se
Se17	1.0	0.110629	0.109158	0.110629	Uiso	?	Se
Se18	1.0	0.110205	0.110205	0.610205	Uiso	?	Se
Se19	1.0	0.110283	0.610283	0.110283	Uiso	?	Se
Se20	1.0	0.110629	0.610629	0.609158	Uiso	?	Se
Se21	1.0	0.610205	0.110205	0.110205	Uiso	?	Se
Se22	1.0	0.610007	0.110007	0.610007	Uiso	?	Se
Se23	1.0	0.609158	0.610629	0.110629	Uiso	?	Se
Se24	1.0	0.610205	0.610205	0.610205	Uiso	?	Se

```
#======================================================================
# CRYSTAL DATA
#----------------------------------------------------------------------
data_Bi14Eu2Se24

_chemical_name_common                  'Bi14Eu2Se24                    '
_cell_length_a                         21.139488
_cell_length_b                         21.139488
_cell_length_c                         21.139488
_cell_angle_alpha                      22.883610
_cell_angle_beta                       22.883610
_cell_angle_gamma                      22.883610
_cell_volume                           1253.527361
_space_group_name_H-M_alt              'P 1'
_space_group_IT_number                 1

loop_
_space_group_symop_operation_xyz
   'x, y, z'

loop_
   _atom_site_label
   _atom_site_occupancy
   _atom_site_fract_x
   _atom_site_fract_y
   _atom_site_fract_z
   _atom_site_adp_type
   _atom_site_U_iso_or_equiv
   _atom_site_type_symbol
   Bi1        1.0     0.197284    0.702029    0.197284    Uiso  ? Bi
   Bi2        1.0     0.197957    0.698185    0.698185    Uiso  ? Bi
   Bi3        1.0     0.198126    0.198126    0.198126    Uiso  ? Bi
   Bi4        1.0     0.197284    0.197284    0.702029    Uiso  ? Bi
   Bi5        1.0     0.698185    0.698185    0.197957    Uiso  ? Bi
   Bi6        1.0     0.702029    0.197284    0.197284    Uiso  ? Bi
```

Bi7	1.0	0.698185	0.197957	0.698185	Uiso	?	Bi
Bi8	1.0	0.301815	0.802043	0.301815	Uiso	?	Bi
Bi9	1.0	0.297971	0.802716	0.802716	Uiso	?	Bi
Bi10	1.0	0.301815	0.301815	0.802043	Uiso	?	Bi
Bi11	1.0	0.802716	0.802716	0.297971	Uiso	?	Bi
Bi12	1.0	0.801874	0.801874	0.801874	Uiso	?	Bi
Bi13	1.0	0.802043	0.301815	0.301815	Uiso	?	Bi
Bi14	1.0	0.802716	0.297971	0.802716	Uiso	?	Bi
Eu1	1.0	0.695502	0.695502	0.695502	Uiso	?	Eu
Eu2	1.0	0.304498	0.304498	0.304498	Uiso	?	Eu
Se1	1.0	0.000000	0.500000	0.000000	Uiso	?	Se
Se2	1.0	0.000000	0.500000	0.500000	Uiso	?	Se
Se3	1.0	0.000000	0.000000	0.000000	Uiso	?	Se
Se4	1.0	0.000000	0.000000	0.500000	Uiso	?	Se
Se5	1.0	0.500000	0.500000	0.000000	Uiso	?	Se
Se6	1.0	0.500000	0.500000	0.500000	Uiso	?	Se
Se7	1.0	0.500000	0.000000	0.000000	Uiso	?	Se
Se8	1.0	0.500000	0.000000	0.500000	Uiso	?	Se
Se9	1.0	0.389954	0.890146	0.389954	Uiso	?	Se
Se10	1.0	0.394979	0.886181	0.886181	Uiso	?	Se
Se11	1.0	0.390495	0.390495	0.390495	Uiso	?	Se
Se12	1.0	0.389954	0.389954	0.890146	Uiso	?	Se
Se13	1.0	0.886181	0.886181	0.394979	Uiso	?	Se
Se14	1.0	0.889911	0.889911	0.889911	Uiso	?	Se
Se15	1.0	0.890146	0.389954	0.389954	Uiso	?	Se
Se16	1.0	0.886181	0.394979	0.886181	Uiso	?	Se
Se17	1.0	0.113819	0.605021	0.113819	Uiso	?	Se
Se18	1.0	0.109854	0.610046	0.610046	Uiso	?	Se
Se19	1.0	0.110089	0.110089	0.110089	Uiso	?	Se
Se20	1.0	0.113819	0.113819	0.605021	Uiso	?	Se
Se21	1.0	0.610046	0.610046	0.109854	Uiso	?	Se
Se22	1.0	0.609505	0.609505	0.609505	Uiso	?	Se
Se23	1.0	0.605021	0.113819	0.113819	Uiso	?	Se
Se24	1.0	0.610046	0.109854	0.610046	Uiso	?	Se